THE IMPACT OF ENERGY ON SUSTAINABLE ECONOMIC DEVELOPMENT IN UGANDA

BY

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List of Abbreviations and Acronyms

$\mu g/m^3$	micro gram per cubic meter
AFRREI	Africa Rural and Renewable Energy Initiative
AIDS	Acquired Immune Deficiency Syndrome
BAT	British American Tobacco Uganda
CDM	Clean Development Mechanism
CEF	Carbon Emission Factors
CERs	Certified emission reduction credits
CH4	Methane
CO	Carbon monoxide
CO2	Carbon dioxide
EAC	East African Community
EDF	Electricite De France
ERA	The Electricity Regulatory Authority
ERPA	Emission reduction purchase agreement
ERT	Energy for rural transformation
ESD	Energy for Sustainable Development
ESMAP	Energy Sector Management Assistance Programme
GDP	Gross Domestic Product
GDP	Gross domestic product
GEF	Global Environment Facility
GHG	Greenhouse gas
GJ	Giga Joules
GNP	Gross National Product
GWh	Giga watt hour
GWh	Gigawatt hour
HEPP	Household Energy Planning Program
HIV	Human Immune Deficiency Virus
ICSID	International Centre for Settlement of Investments Disputes
IMF	International Monetary Fund
JI	Joint implementation

KCCL	Kasese Cobalt Company Limited
kVA	kilovolt ampere
kW	kilowatt
kWh	kilowatt hour
$kWh/m^2/day$	kilowatt hour per square meter per day
LEAP	Long-range Energy Alternatives Planning
LPG	Liquefied petroleum gas
MIGA	World Bank's Multilateral Investment Guarantee Agency
MJ	Mega Joules
MJ/kg	Mega Joule per kilogram
MOEMD	The Ministry of Energy and Mineral Development
MOWHC	Ministry of Works, Housing and Communication
MW	Mega Watt
MWh	Megawatt hour
N_2O	nitrous oxide
NEMA	National Environment Management Authority
NEPS	National Electrification Planning Study
NGO	non-governmental organisation
PCF	Prototype Carbon Fund
PEAP	Poverty Eradication Action Plan
PJ	Peta Joules
PM	particulate matter
PM_{10}	PM with a mass medium aerodynamic diameter less than 10 micrometers
PMA	Plan for Modernisation of Agriculture
PPA	Power Purchase Agreement,
PV	Photovoltaic
REA	Rural Electrification Agency
SCOUL	Sugar Corporation of Uganda Limited
SD	Sustainable development
TCD	Tonne cane per day
tCO_2	Tonne of CO_2

TV	Television
UEB	Uganda Electricity Board
UGX	Uganda shillings
UIA	Uganda Investment Authority
UNDP	United Nation Development Programme
UNEDO	Uganda National Energy Development Organisation
UNFCCC	United Nations Framework Convention on Climate Change
UPPPRE	Uganda Photovoltaic Pilot Project for Rural Electrification
UREA	Uganda Renewable Energy Association
US$	United States dollars
USIKA	Type of ceramic stove
VITA	Volunteers in International Assistance
WB	World Bank
Wp	Watt peak
MEAD	Model for Analysis of Energy Demand
ENIS	Energy Information System

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Abstract

Energy is a very important resource for national development. Uganda's energy mix comprises mainly biomass, petroleum products and electricity. Biomass is the main source of energy, contributing 92.3%. Petroleum contributes 6.3 % and electricity 1.3 % of the total energy consumption. The contribution of other forms of energy; wind, solar and biogas is negligible. Biomass is mostly used in households and small-scale industries. Petroleum and electricity are used in large-scale industries and the commercial sector.

It was envisaged that the results of this study will be an important input into the National Vision, developed by The Ministry of Finance Planning and Economic Development, for national development to the year 2025. The base year for this study was 1999. Several other studies, have been carried out by foreign firms in the areas of energy supply and demand forecasting, but the participation of local personnel is limited and this makes it difficult for follow-up action. The National Vision was focused on economy while petroleum and biomass were not given the priority they deserve.

The objective of the study was to determine energy demand and supply options that could be used in Uganda, and to estimate the optimum energy mix for sustainable development. The effect of energy resources on the environment was analyzed. Questionnaires, interviews, deskwork and measurements were the research instruments used. A detailed picture of energy demand and supply for Uganda was assembled from published data, and in case of households, industrial, commercial and transport sectors, from a survey that was conducted. The efficiencies of stoves were studied during the research to determine the impact of their use in households. The LEAP energy model was used to process the data obtained in order to predict future energy demand from an accurate baseline. Three scenarios were considered namely; the Status quo Scenario, the Low Case Scenario and the Enhanced Scenario. Future energy demand is driven by elements such as population growth rates and GDP as well as by the introduction of new, more efficient technologies. It was therefore necessary to investigate trends and development in all sectors of the economy, in order to make accurate predictions of energy demand in the future.

The findings indicate that there is lack of electric power supply and high cost of petroleum products. The demand for electricity outstrips supply. Petroleum consumption is increasing at a high rate and consequently, it will increase the demand for foreign exchange. Biomass consumption is higher than sustainable yield, and leads to over exploitation of biomass resource base and environmental degradation. Land clearance for agriculture and grazing is one of the major causes of deforestation. There is limited awareness of the looming biomass crisis and general energy shortage. Uganda will continue to experience load shedding for the next five years. This makes the country unattractive for foreign investors. Biomass demand growth rate is above the sustainable yield, and will lead to severe biomass shortages in the foreseeable future.

Various scenarios were used for energy demand projection. The energy mix for the year 2025 depends on the scenario under consideration. In the Low Case Scenario energy demand will increase by 2.3 fold from 280 PJ in the base year to 648.1 PJ in 2025. In the Status quo Scenario, energy demand will increase by 2.6 fold to reach 726.2 PJ. In the most favourable case, the Enhanced Scenario, energy demand will be 781.4 in the 2025. Biomass will vary between 78.9% and 88.1% while petroleum products will vary between 9.4% and 17.1% while electricity contribution will be between 2.4 % and 4 %, where the low and high values are for the Low Case Scenario and Enhanced Scenario respectively. Biomass will be the largest source of energy in the foreseeable future. The anthropogenic emissions will increase from 2.7 million tonnes in 1999; the base year to between 8.1 million and 10.7 million tones depending on the scenario under consideration.

The study concluded that total energy demand is growing faster than supply, leading to the unsustainable exploitation of the biomass resource base. Electricity demand outstrips supply that leads to present load shedding. There is limited local energy planning expertise. Consequently, there is an over-dependence on other countries for expertise and resources. There is a lack of coordination of energy-related activities, which results in time, human and financial resources not being used optimally. The Government has been receiving money in the form of grants from international partners in development to formulate its energy related policy. This forces the country to make compromises which could be against the national interest in the long term.

It is recommended that it is important to assess the energy demand and make the projection, so that necessary measures can be taken in time to limit the adverse effect of energy shortages in the future. The government should seek for assistance from international financial institutions in order to devise the most optimum method of its utilisation. There is a need to develop national capacity in energy planning. Interdependency and effective mobilisation, sensitisation through awareness campaigns, coordination of energy related activities. Staff training programmes are required. During the design and implementation of the energy training programme critical stakeholders should be consulted. The government should increase funds for energy-related programmes. Furthermore the government should enable effective participation of the Ministry of Energy and Minerals Development, institutions of higher learning, the few local experts, NGOs, energy users and the general public in energy related programmes.

CHAPTER ONE
INTRODUCTION AND BACKGROUND

1.0 Introduction

This thesis presents the analysis of energy demand and supply options for the sustainable development of Uganda and proposes a number of viable alternatives to ensure overall sustainable development. Uganda has experienced relatively high economic growth rates over the last decade. This has meant that demand for energy has also been growing. It is imperative to note that energy is a crucial ingredient for economic development. Concurrently, population increase is putting pressure on the land and other natural resources. There is severe shortage of commercial energy in many parts of Uganda. The shortages of energy to sustain the rate of economic development has forced the government to search for solutions to develop the available energy resources, to create a conducive environment; put in place appropriate policies and to allow private investors to play an active role in the energy sector. No doubt, some of the policies will have a long-term impact on the socio-economic development of Uganda.

1.1 Background

Uganda is located on the eastern side of Africa, bordered by Sudan to the north, the Democratic Republic of Congo to the west, Rwanda and Tanzania to the south and Kenya to the east. Uganda is a land-locked country. Topographically, much of the country consists of a plateau, with the entire country lying at 900 meters above sea level. It covers a total surface area of 241,551 square kilometres, of which 197,610 square kilometres is under land and 43,941 square kilometres under water and swamps. Uganda shares a number of large fresh water lakes with neighbouring countries. Lake Victoria is shared with Kenya and Tanzania, lakes Albert and Edward with the Democratic Republic of Congo. Together with most of the inland rivers, these lakes form the River Nile basin. The estimated population is 24.7 million (2002), of which 14.5 percent live in the urban areas and 85.5 percent live in the rural areas.[1] The national population growth rate is 3.4 [2] percent per annum. The population growth rate is currently 5.0 percent per annum in the urban areas, while in the rural areas it is 3.1 percent. The overall population density is 126 persons per square kilometre.

There is high increase in urbanisation. One of the implications is obviously that the energy demand in urban areas can be expected to grow rapidly in the next decade. Therefore, the demand for domestic energy in particular will outstrip the supply if appropriate measures are not taken in time.

Administratively Uganda consists of 4 regions and 54 districts at the time this study was conducted (See Appendix A, Figure A1.1). A total of 3,434,177 households exist in the country, of which 446,980 households are found in the urban areas and the vast majority of 2,987,196 live in the rural areas.[3] About 52.1 % of the population is aged less than 15 years. This percentage is higher in the rural areas where 53 % of the population is aged less than 15, while the corresponding ratio in the urban areas is only 45%.[4]

1.2 The Energy Situation

One of the main indicators of economic development of a country is her per capita energy consumption. The total energy consumption of Uganda in 2003 was estimated to be 350 Peta Joules.[5] Per capita energy consumption is 13.66 Giga Joules .This is considerably very low. The development of a country can often be gauged by its level of consumption of commercial energy. Uganda's commercial energy consumption of 0.97 Giga Joules per capita is low by any standard.[6]

Uganda's energy mix comprises biomass, petroleum and electricity. Biomass is the main source of energy contributing about 92.9 %, petroleum 6.0 % and electricity 1.1 %.[7] Biomass is mostly used in the rural households.

1.2.1 Electricity

Uganda faces significant constraints to economic development due to lack of sufficient electric power. Only 4.1 % of the population have access to grid electricity. This is far below the average even in Africa, which stands at 18%. Electrification is very slow and electric power is unevenly distributed. Whereas only 20% of the population in the urban areas are supplied, less than 1 % of rural areas are connected to the grid. For instance, in 1996 it was estimated that 2,929,100 households in rural Uganda did not have access to electricity.[8]

The country is at present experiencing a high rate of growth in electricity consumption. There is considerable high demand. At present, the national demand for electricity is estimated at 330 MW. This is caused by rapid economic development. GDP real growth rate is 6.8 % per annum over the period 1990 to 2003.[9] In Uganda electricity is mainly supplied by the hydro plant at Nalubaale Power Station with an installed capacity of 180 MW and Kiira Power Station with a potential capacity of 200 MW. When the Kiira project is completed, the total installed capacity may be 397 MW, but this figure may not be attained due to the hydrology of Lake Victoria.

Uganda's installed capacity is 318 MW. However, the operational capacity is 265 MW due to the recent prolonged drought in the region. Even the power export to Kenya was suspended. The Uganda System Operator (Uganda Electricity Transmission Company Limited) is negotiating with Kenya to import 10 - 25 MW of power from Kenya's thermal generation during peak time. [10]

As a short-term measure, the Government has contracted a firm to set up thermal generators that will provide 50 MW of power to curb shortages in 2005. But this can only be a stopgap measure because thermal power is three times as expensive as hydro-electric power to generate. [11]

1.2.2 Biomass

Biomass is primarily and traditionally the main source of energy in Uganda. It is estimated that biomass contributes about 92.9 percent of the total energy requirement in Uganda.[12] In 1994, rural households used about 87.8 percent of the total biomass energy. Industrial and commercial sectors consumed about 7.7 percent, while the urban households and institutions used the rest.[13] The consumption of biomass is expected to increase as the population and economic development increases.

1.2.3 Petroleum

Petroleum is the main source of energy for transport and to a lesser extent used in industries. It is also used widely for lighting in households. All petroleum products are imported. Adequate supply of petroleum products is necessary for sustaining the present economic growth. This too has a direct impact on the balance of payments. So, the provision of incentives for improved efficiency in supply is critical. However, the sector that has been liberalised before putting in place a policy that will ensure that the public gets a fair price. There was removal of controls on foreign exchange and petroleum prices in 1993 and 1994 respectively and the Government has provided an incentive for supply rationalisation.

The government divested itself from the petroleum sub sector in 1994. With liberalisation of the petroleum prices (in January 1994), all price controls were eliminated. The oil companies are operating on either oligopoly or cartel systems of marketing. The Department of Petroleum in the Ministry of Energy and Mineral Development appeared like they cannot determine a fair price; hence the companies could be making windfall profits.[14] In 1999, importation of petroleum products contributed 19.2 % of the total revenue collection.[15] Petroleum is a major contributor to the national revenue in terms of taxes. Uganda's annual import bill is estimated to be US$ 160 million, accounting for about 20% of the total export earning.

The government lacks the human and other resources to enforce efficient use of petroleum. The government has neither equipped itself with adequate legal and punitive power, nor built an effective capacity to handle control mechanisms. The challenge facing the Ministry is how best to manage deregulation, liberalisation and expansion of petroleum marketing and retailing in the best interest of the population. As a consequence, an oligopolistic situation has emerged in the petroleum marketing sector, with a couple of companies that act as leaders and set prices while others adopt the same price level after a certain interval. The government is unable to intervene against the price mechanism. Presently marketing and distribution is within the private sector with eighteen companies involved in the marketing of petroleum products. The leading companies are Shell, Caltex and Total. The scenario appears such that small companies will always have to comply with the pump prices set by the big ones.

1.2.4 Renewable Energy

Uganda is endowed with the various sources of renewable energy, including hydro, solar, biomass, biogas and wind energy. Renewable energy development has recently received more attention in Uganda. However, renewable energy plays a minor role in Uganda's energy consumption. Only a fraction of these resources are utilised due to the problems such as lack of co-ordination and little exchange of information and experience, limited follow-up and very limited monitoring and evaluation. Renewable energy therefore provides a negligible contribution to the total national energy supply, with the exception of biomass.

1.2.4.1 Solar Energy

In spite of the abundance of solar energy throughout the year, its use has been confined to traditional crop drying, a practice which is common in most parts of the country. This energy sector is not developed as yet. Its role is insignificant apart from a few cases where it is the only available source of electric energy. This is particularly so in the remote areas, not connected to the grid. Notably, missionary establishments have resorted to solar energy applications for lighting, refrigeration and water pumping in rural institutions. The dissemination of this technology in Uganda is currently hampered by its relatively high costs. However, there is growing interest in solar energy applications. The main emphasis has been low power electric energy generation for the affluent rural households and institutions.

There are major initiatives to change this situation. The Ministry of Energy and Mineral Development is implementing two projects, namely, the Uganda Photovoltaic Pilot

Project for Rural Electrification (UPPPRE) and the Africa Rural and Renewable Energy Initiative (AFRREI). AFRREI is funded by the World Bank.

UPPPRE is intended to demonstrate and establish financial and institutional mechanisms to provide solar photovoltaic-based electrical services on a commercial base to households, businesses and communities in the rural and peri-urban areas of the country. The target groups are areas that are not projected for grid-based electricity in the foreseeable future. The project is however based on the assumption that people living in these areas should have both the ability and willingness to pay for the unsubsidised cost of the system. It is expected that the UPPPRE will lead to a large scale national programme to promote photovoltaic based rural electrification involving additional capital from local financial institutions, development agencies and private investors. Overall, the project aims are to:

- Improve the quality of life in rural areas and facilitate significant rural non-farm income by accelerating rural electrification, including from photovoltaic systems, with a tentative target of increasing rural electrification access from about 1% at present to about 10 % by the year 2010
- Develop Uganda's indigenous, renewable energy resources on a cost-effective basis, with a tentative target of about 70 MW of power generation from small renewable energy resources by the year 2010.

Nevertheless, it is imperative to note that there is low dissemination of information about renewable energy in Uganda. The Uganda Renewable Energy Association (UREA) has endeavoured to play a big role in dissemination of information on renewable energies in Uganda. At present however, the association is more focused on solar energy because of the ongoing projects in solar energy systems.

1.3.4.2 Biogas

Biogas technology was introduced in Uganda in the early 1980's by the Churches. Several digesters were constructed in different parts of the country. The construction was funded by the Church of Uganda and in some cases the Ministry of Energy and Mineral Development as energy projects. The most common types of the digesters were the Indian floating types, Nepalese types and the Chinese digesters. Some of these digesters acted as demonstration units. Most of the digesters were constructed in the Mbarara and Bushenyi districts in the western region and Kumi and Karamoja districts in the eastern region of Uganda.

All these digesters worked for a number of years until they experienced problems, some of them due to lack of proper maintenance, while others never functioned at all. Among the reasons for failure is lack of adequate capacity left behind to monitor and maintain these digesters. There could have been other reasons for their failure such as negligence, but no diagnosis has ever been carried out. In spite of the failures, there are organisations and individuals that are still interested in biogas technology. The initial high cost of installation is a factor hindering utilisation of this technology. Recently there was renewed interest in the training of local technicians in the construction of biogas digesters by the Ministry of Energy and Mineral Development, with support from the Chinese Government.

1.2.4.3 Wind Energy

The wind regimes in Uganda do not favour electric power generation. The wind is just enough to be used for windmills suitable for irrigation and animal watering purposes. There are few companies that install windmills for water pumping in Uganda. Several ranches, Churches and NGOs have installed windmills to provide water to livestock and humans over the past several years. Three types of windmills are dominant in Uganda. These include the Kenyan built Pwani windmill, the Kenyan-built Kijito and the South African and Australian built Southern Cross.[16]

Some problems have occurred with the utilisation of wind energy. At times the NGOs that install windmills have little understanding of the wind regimes of the locality. There is poor dissemination of information regarding the wind regimes in Uganda in general. As a result, some windmills are installed in poor locations, such as valleys where the wind may not be enough for water pumping. Such shortcomings may discourage a potential user of the system. However, there are a number of windmills installed in Karamoja and Kotido Districts that are working successfully.

1.2.4.4 Ethanol

Ethanol is produced from sugarcane. Uganda has three major sugar estates and a number of sugarcane out-grower plantations located across the country. With a total planted area estimated at over 27,000 hectares, and a total crushing capacity of the three factories estimated at over 7,000 tons of cane per day, over 133,000 tons of molasses can be produced annually. There is considerable potential therefore for producing ethanol, which can be blended with petrol to produce gasohol. A considerable investment is required to develop this source of energy.

1.3 Structure of the Economy

Uganda has over the last decade experienced strong economic progress, with average GDP real growth rates of 6.8 % per annum over the period 1990 to 2003[17] and an average inflation rate of about 5.9 %. In 2003/04, per capita GDP was estimated to be US$ 250.[18] Uganda's export base is narrow, it largely depends on agricultural exports, which are highly dependent on the World market. This translates into a poor balance of trade and current account situation. The trade balance situation suggests that the efforts made so far have not made the economy resilient.

As already argued, energy is a key sector in the economy. It is a major component of the country infrastructure and is closely linked to development because it supports both economic activities and social development. Energy also contributes significantly to financing public expenditure as petroleum products provide about 25 percent of the total fiscal revenue, while electricity sales contribute around 1 percent of the total revenue.

The Government of Uganda is implementing an economic reform programme assisted by the World Bank and the IMF. The main thrust of the programme is to promote prudent fiscal and monetary reforms, macro-economic stability, and reform of the labour market, improvement of incentives to the private sector and reform of the regulatory framework.

A major policy reform came into force in 1991 with the passage into law of the Investment Code. The objective was to promote, facilitate and monitor both foreign and domestic investment and rationalise procedures for investment approval and introducing additional incentives. The Uganda Investment Authority (UIA) provides services for issuing investment licences, certificates of incentives and registration of transfer of technology agreements. The incentives include duty and tax-free facilities, duty drawback for export industries and exemption from corporation tax, withholding tax and tax on dividends. The implementation of the adjustment measures and introduction of the Investment Code have produced significant microeconomic gains and placed the economy on a path of sustainable low-inflationary growth. Now Uganda has revised that plan to offer depression allowances geared more towards bigger investors.

1.4 The Major Sectors of Economy

There are three sectors that contribute to the economic development of the country and that have a direct bearing on energy, namely, agriculture, industry and transport. The mining sector is not prominent at present.

1.4.1 Agriculture

Uganda is endowed with fertile soil and favourable agro-climatic conditions. That is why agriculture is the mainstay of the domestic economy and a backbone of the whole economy. In the financial year 2003/04, agriculture accounted for 38.5 percent of the GPD, the industry 19.4 percent and the service sector contributed the balance. [19] Given the structure of the economy, industrial development in Uganda must initially be agro-based. It would be a mistake to pursue industrial growth without due regard to the health of the agricultural sector which is prone to climatic changes such as El Nino, La Nina, drought and other factors like the World market. Particularly relative to energy sector is that Uganda needs to step up the processing of agricultural commodities, most of which are exported as raw materials. The demand for processed agricultural products will come from subsistence farmers drawn more and more into the market economy, urban consumers whose ranks are growing at a rate of 5 % per annum and foreign buyers. It is important that such activities should bring about development of small scale-industries in the rural areas.

Uganda's agricultural resource base, which provides the key inputs for agro-processing, is abundant. On other hand, there are many limitations that have hampered this sector from realising its abundant potential. Poor infrastructure, unavailability of cheap and reliable energy supply, lack of capital and poor storage facilities are among the obstacles that hinder agricultural development in the rural areas. Reforms are required that can increase yield in the agricultural sector through improvement in the entire chain of agricultural support services including transport, processing and marketing. Energy availability can easily facilitate this transformation process.

Uganda is richly endowed with freshwater resources, making fishing an important economic activity. Despite the abundant fisheries resources, there are problems including unreliable power supply, poor processing facilities and weather-induced high spoilage rate, which undermine the output. The key opportunity in investment lies in the area of fish processing for exportation. Fish is the third largest foreign currency earner after coffee and tourism. There are growing exports of processed fish and horticulture.

1.4.2 Manufacturing

In order for Uganda to develop, it has to become industrialised. Industrial development should go hand in hand with agricultural development. The average contribution of manufacturing to the GDP has been increasing steadily. The contribution of manufacturing grew from 5.5 percent in 1990 to 9.7 percent in 2002.[20] The percentage contribution is still low compared with other countries with low human development indicators where the manufacturing sector's contribution to GDP was 19% in 1999.[21]

During the implementation of the recovery programme in the late 1980's, the government began to develop a medium term strategy to rehabilitate private industrial plants and to reform industrial parastatals. At the time, the government began to relax restrictions on prices and profit margins of items other than public utility tariffs. With respect to the parastatals, the strategy was to encourage divestiture and improve operation efficiency of the enterprises that remained within the public sector.

Manufacturing has a strong link to energy consumption in general. The rebound in manufacturing activities is linked to the rejuvenation of the economy. One major factor is the introduction of a more industry-friendly code which provides a general set of investment incentives, guarantees profit repatriation and provides protection against expropriation of assets. In this connection, the Uganda Investment Authority was established in 1991, to facilitate investment, issue investment licenses and certificates of incentives, to determine the terms and condition imposed on the investments, and make recommendation to the government on national policies towards investments [22].

1.4.3 Industrial Production

Uganda has a low level of industrialisation, evidenced by the fact that its contribution to GDP is less than 15%. Yet industrialisation is a key to national economic development. The availability of reliable energy can boost this sector. That be as it may, the sugar, beer, soft drinks and soap and oil industries are performing well although the manufacturing sector indicated decrease in growth rates from 9.4% in 1999 to 4.1 % in 2002 [23]. The most active industries are food processing, chemical products and soap and steel products. Uganda's industrial sector has high import content in manufactured and finished products. The implication is that should there be depreciation of the Uganda shilling, the pace of industrial expansion will decrease.

1.4.4 Transport

Transport plays a major role in economic activities, it aids and facilitates growth and development in all other sectors of the economy. Effective transport provides support to increased agricultural, industrial production, trade and tourism, social and administrative services and ultimately, promotes growth and overall economic integration. The availability of an adequate transport infrastructure is a prerequisite for poverty alleviation, attraction of private investors and facilitation of regional economic integration and international trade.

In Uganda, rural feeder roads are the principal means of vehicular access to rural areas where the majority of the country's poorer population live. Though urban roads are very necessary for a drive to industrialisation for they promote industrial development, trade and commerce, it is important that access to rural areas and economically-productive areas be improved.

1.4.5 Mining

Development in the mining sector is slow compared to other sectors. The major mineral-rich areas of the country are concentrated in the south-western and south-eastern region. Some of the minerals of economic importance are gold, copper, cobalt, tin, salt, phosphates and iron ore.

The main issue pertaining to the mining sector in Uganda has been the absence of a conducive environment and the narrow scope of the policies and legislation, related to prospecting and mining activities. The absence of major infrastructure development and power in these areas also hinders development in this sector. Mining and quarrying growth reflects the buoyant position of the construction industry, in housing and road and other civil works. Most of the mining and quarrying is done by small-scale industries. Unlike other industrial sectors, the mining sector does not consume a lot of energy in Uganda.

There are significant quantities of known iron deposits in the Kabale and Kisoro districts. At Muko it is estimated that there is a 3.8 million tonne high-grade iron ore deposit. Even then, Uganda has not developed a notable steel industry. The major constraints are the large investments required to develop an integrated steel plant, and lack of infrastructure. Currently, the major operational plant is the Steel Rolling Mills in Jinja, which depends on scrap material. There are two other medium-sized steel rolling mill plants, which are working intermittently, the reason being that they rely on imported steel billets. The fourth plant, East African Steel Corporation is a company that could be operational within the next three years. The operation of all these industries will highly depend on the availability of reliable electricity.

1.4.6 Petroleum Exploration

Although petroleum production has not been established in Uganda, the hydrocarbon generating capacity of its Rift Valley basin is very evident. The first serious evaluation of Uganda's hydrocarbon reserves was made in 1925. Geological and geophysical work todate has indicated that source rocks and maturity are guaranteed in Albertine Graben in western Uganda. There are five confirmed surface oil manifestations in the Uganda part of the Albertine Graben and these include two live oil seeps on the Victoria Nile near Para, the Kibuku seep and the Kibiro seep on the shores of Lake Albert. Gas seeps have also been reported in the lakes. Test drilling was started in September 2002.

Surprisingly, there is lack of convincing data to entice big investors in the oil business. Sporadic insecurity in western Uganda in the recent past was another discouraging factor to potential investors. Moreover, the location of the sites is over 1600 km from the coast. So far, the companies that have shown interest in petroleum exploration are RSM Production Company of Denver, United States; Hardman Petroleum (U) Pty Limited of Australia, Energy Africa of South Africa and China National Petroleum Corporation, which already has significant operations in Sudan.

1.5 Poverty Situation

Uganda is one of the poorest countries in the world. Her GDP per capita for 2001 was about US$ 260, placing Uganda as the 21st poorest country in the world.[24] Uganda compares poorly with her neighbouring countries in terms of GDP per capita, mortality rates, life expectancy and social services. The Government has developed a Poverty Eradication Action Plan (PEAP) and has attained some success so far. According to statistics from the Bank of Uganda, absolute poverty was reduced from 56% in 1992 to 35% in 2000. However, the absolute number of people below the poverty line fell marginally from 9.3 million to 7.8 million in 2000.[25]

Poverty in the Ugandan context is defined as the lack of basic necessities of life, namely: food, clothing, shelter, and other needs including education and health. The poverty line is a measure of poverty. In the Ugandan context it reflects how much it costs a person to get the basic requirements of life mentioned in the definition of poverty. For example, the cost of meeting the basic food requirements in Uganda is determined by the cost of obtaining 3000 calories a day for men aged 18-30 years who are engaged in moderate work. This cost is based on a typical diet of the poor in Uganda.[26] Poverty is more severe in Northern and Eastern Uganda. The government has recently proposed to target public investments and interventions in these regions. However, slow implementation by district and line ministries has hampered effective service delivery.

Poverty is multi-dimensional with different facets. For instance, local insecurity is a major concern for the poor. Access to clean water, lack of health facilities, bad transport, inefficient education and corruption constitute other factors which increase poverty. The government often allocates insufficient funds for the social sector, generally. According to UNDP, for a country to do well in human development, not less that 40% of public expenditure should be towards social services. In Uganda, an average of only 10 % is allocated for social services including health and education, only 3% is effectively used in priority areas, the rest being lost through corruption. This compares badly with the sub-Saharan Africa average allocation for social services which is about 20%. [27]

It is believed that increasing agricultural productivity is essential to poverty reduction. For that reason, the Government of Uganda has given the sector increased priority. Presenting a special plan for the modernisation of agriculture, supporting rural small holders and bringing them to market are prominent features of the plan, as is improvement of the environment for private sector investment in agriculture. All this means that energy should be made available to facilitate the processing of agricultural products.

The morbidity and mortality associated with the HIV/AIDS infection has affected the labour force and capital development. As an indirect economic cost, national productivity is hampered through loss of life and future economic input. One of the sectors that are mostly prone to losses in human life is the agriculture sector where about 80% of the population is employed. HIV/AIDS has had a devastating effect on the households, prompting the government of Uganda to target the reduction of the HIV/AIDS prevalence from 6% at present to 5% by the end of 2005 [28] this is yet to be achieved.

1.6 Sustainable Development

Sustainable development is a relatively new development concept. Although there is no universally accepted definition of sustainable development, often quoted is the definition of the World Commission on Environment and Development, whereby sustainable development is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs".[29] Within this definition are two key concepts.

- The concept of "needs", in particular the essential needs of the world's poor, to which overriding priority should be given; and
- The idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.

1.6.1 The Objectives of Sustainable Development

Economic developments contribute to a developing country's sustainable development objectives through:

- Transfer of technology and financial resources;
- Sustainable ways of energy production;
- Increasing energy efficiency and conservation;
- Poverty alleviation through income and employment generation; and
- Local environmental benefits.

Human efforts towards economic growth present both opportunities and threats for environmental conservation and sustainable development. While maintaining environmental quality is an essential part of development, in practice there is considerable tension between economic and environmental objectives.

Environmental benefits would include reduction in air and water pollution through the reduction in use of fossil fuel, improved safe water availability and reduced soil erosion. Social benefits would include creation of employment opportunities in target regions or income groups, efficient local energy use as well as improved health and poverty alleviation. All these have implications for the energy demand and supply.

Uganda's government has expressed commitment towards sustainable development and concerns are recognised at policy, planning and programme levels. This is reflected in the visions, missions, and objectives of various national strategic frameworks and plans. However, resources to support such programs in Uganda remain limited. Although Uganda does not have official sustainable development criteria, based on the current national policy environment, the following can be considered as key issues related to sustainable development:

- poverty alleviation
- economic and social development
- primary health care
- safe drinking water
- environmental protection
- universal primary education
- modernizing agriculture
- strengthening good governance and security.

Energy has a crucial role to play in most of the areas stated. For example, the availability of affordable energy will stimulate development by creation of jobs that will lead to social and economic development both in the rural and urban areas. The availability of energy is essential for the preservation of vaccines for immunization, and for the provision of basic needs such as water and light for communities and schools mostly in the rural areas. The agro processing industry can be promoted in rural areas if energy is available at a reasonable cost.

1.6.2 Sustainable Development Indicators

It is imperative that Uganda identifies a set of indicators to be used to monitor the investments that will contribute to sustainable development. In identifying these indicators, the requirements for sustainable development must be borne in mind. Some of the basic features on the three aspects of development, in relation to energy, are:

- Concentration of particulate matter in the atmosphere
- Transfer of cleaner production technology and practise that will reduce emissions, wastes and environment degradation.
- The decreasing use of domestic fuel wood and charcoal.
- The number of jobs created per year.
- The per capita income and the number of people living below the poverty line.
- The percentage of the population with access to safe water, with adequate literacy, and access to health care facilities.

The entire above are related to some institutional framework.

1.7 Energy Institutions

The Ministry of Energy and Mineral Development is concerned with energy policy initiation and implementation in Uganda. The mission of the Ministry is to promote and ensure the rational and sustainable development and utilisation, and the effective management and safeguard, of energy and mineral resources, for social and economic development. The department of Geological Survey and Mines is responsible for activities related to the prospecting and mining, petroleum and geological resources.

The Department of Water Resource Management falls under the Ministry of Water, Land and Environment. Among its responsibilities, is to conduct a hydrological study of any energy project. The Department of Forestry is concerned with the management, protection, extension and development of forests.

The National Environment Management Authority (NEMA) is the principal agency responsible for overall co-ordination, monitoring and supervision of all environmental activities. This implies that to develop a hydro power plant, investors will have to fulfil the requirements of a number of different ministries before acquiring licenses.

The Electricity Regulatory Authority (ERA) is the regulator of the electricity industry in Uganda while the Rural Electrification Agency (REA) is the implementation agency for the Energy for Rural Transformation Project under the Ministry of Energy and Mineral Development. All these impact on the energy situation in the country.

1.8 Energy Policy

Uganda has a comprehensive and detailed policy on energy.[30] The Electricity Act is focused on electricity [31] and its objective is to liberalise and introduce competition and active participation of the private sector in the Ugandan power sector, to transform the sector into an efficient industry and to supply reasonably priced and reliable power and to make its full contribution to the economic and social development of Uganda.

The rural electrification policy is to be formulated with the main aim of increasing access to electricity by the rural community. There are ongoing studies in the other sectors of energy namely biomass, renewable energy and petroleum under the Energy Advisory Project. The Project is implemented by GTZ with assistance from the Federal Republic of Germany. The main purpose of the project is to assist the Energy Department to efficiently and effectively fulfil its policy development, planning, co-ordination, information monitoring and evaluating functions. There are other legislations such as the Land Act and the Investment Code that also affect the development of the power sector.

1.9 Energy and the Environment

The environmental degradation associated with the production and consumption of energy world wide today, particularly fossil fuel, threatens human health and quality of life, and affects the ecological balance. Fossil fuels and traditional use of other forms of biomass such as fuelwood, charcoal, agricultural waste and cow dung, are major contributors to serious environmental and health problems in most of the developing countries.

1.9.1 Indoor Air Pollution

Most households in Uganda depend on wood fuel and agricultural waste (in the rural areas) and charcoal (in the urban areas) as the major source of energy for cooking. These biomass fuels cause dangerous indoor air pollution which is most common in developing countries. Indoor air pollution from biomass fuels has become a worldwide concern. In most cases the kitchens are not well ventilated as the result, the burning of biomass fuels in traditional stoves in such an environment, and inefficient process of biomass combustion, results in the release of smoke containing large amounts of toxic pollutants such as carbon monoxide, nitrogen oxides, sulphur dioxide, aldehydes, dioxin, polycyclic aromatic hydrocarbons and particulate matter.[32] These pollutants are the main causes of health problems in households

Indoor air pollution is one of the major causes of death and disease in the world's poorest countries due to the release of harmful pollutants. In most research carried out worldwide it was indicated that indoor air pollution is a contributory cause of over 1.5 million deaths in developing countries per annum.[33] In most cases rural women and children are the most at risk, since they spend long time close to the source of emission, especially during cooking. The place of cooking is usually a poorly ventilated kitchen.

1.9.2 Outdoor Environment

Greenhouse gases come from the entire human activity; agriculture, forestry, manufacturing, transport and energy generation. Carbon dioxide (CO_2) is the major gas that is emitted by the fossil fuel cycle and methane during fermentation process of organic waste. Greenhouse gases (GHGs) are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorbs and re-emits infrared radiation.

Global warming is thought to be among the effects of CO_2 and other greenhouse gases emissions. Interestingly, the energy sector is a major contributor to GHGs in most of the countries which depend on coal and other fossil fuels for their energy generation. Indeed the least developed countries are very vulnerable to climate change. Most of these countries depend on their natural resources for their livelihood, which is now being threatened by climatic changes.

1.10 International Protocols

The problems associated with energy and the environment has been addressed in a number of International Protocols. The United Nations Framework Convention on Climate Change (UNFCCC), for one, promulgated at the 1992 Earth Summit in Brazil commits most nations of the World to deal with the mitigation of climate change by limiting the emissions of GHGs and addressing appropriate responses to mitigate or adapt to global climate change.

The cost of reduction of greenhouse gases emission in developed countries is very high. That calls for need of developing mechanisms to reduce the costs. A central element of the Kyoto Protocol is the provision for international mechanisms that allow for flexibility in achieving GHG emission reductions for the 2008-2012 time period which is commonly referred to as first commitment period. The principle supporting these mechanisms is found in the UNFCCC, which called for cost-efficient policies which could be applied worldwide. The rules will set and are to be based on the economic status of the county. The main objective is to solve a global environmental problem. [34]

There are different mechanisms that were introduced to favour cleaner technologies that reduce greenhouse emissions. The resulting amount of reduction in greenhouse gasses is assigned units depending on the mechanism under consideration. Joint Implementation (JI) is one of the forms of flexibility mechanisms which allow for transfer or acquisition of emission reduction units (ERUs) as result of implementing climate change mitigation projects under Article 6 of the Kyoto Protocol. It is based on the 1992 UNFCC Convention, wherein countries included in Annex I. The listed (developed) countries have special commitments to limit their emissions of greenhouse gases under the Convention.

The JI concept has evolved based on ERUs which could be credited to an investor country, in most cases a developed country, for reduction projects realised in a host country. JI is being implemented between the European Union and countries in economic transition and Russia. The emission reduction credited would be based on actual, reduction, or sequestration of GHGs.[35]

The Clean Development Mechanism (CDM) is one the forms of flexibility mechanism defined under Article 12 of the Kyoto Protocol. It permits the purchase by Parties of certified emission reduction credits (CERs) that can be generated from project activities in developing countries to contribute to compliance with part of their quantified emission limitation and reduction commitment under Art. 3. For the purchase of the credits to take place, there should be an agreement between the two parties.[36] The CDM is most favourable mechanism for both developing and least developed countries.

The International Emissions Trading as practised in the developed countries is not based on the transfer of reduction "credits" but on the trading of emission "rights" or allowances. The developed countries can transfer between themselves emission rights from those countries whose emissions are below there national quotas. [37]

Uganda can benefit from CDM funds if public awareness of CDM is increased by capacity building to analyse and assess projects, and if there is more engagement of the government and the private sector in discussion on the mechanism, particularly on the issues of its operation and design. This would go a long way in addressing the energy situation in Uganda, in the long run. For although Uganda is a small emitter of GHGs by international standards, it needs an inventory of its GHG emissions to meet its commitment as a signatory to the UNFCCC. This affords the opportunity to develop projects that can be internationally sponsored via organisations such as the Global Environment Facility, and the Clean Development Mechanism, through the Prototype

Carbon Fund (PCF) and other buyers of emission credits. It will facilitate climate-friendly investments by pioneering environmentally credible emission reduction.

1.11 Energy Models

The use of system models in most developing countries has become increasingly popular in the energy sector to investigate energy economy interaction, regulatory policies, conservation and environmental issues. The complexity of the model depends on the expected output of the parameters under investigation. However, there are less complex models like Long-range Energy Alternatives Planning (LEAP) which is being used by developing countries. Data presentation and analysis can be facilitated with the use of a micro computer and can enable both energy projection and evaluation of various energy policy options and scenarios.

1.12 The Purpose of this Research

This research has addressed the effect of energy on sustainable economic development. The thesis is that an integrated energy plan can be formulated by modelling a number of scenarios. These scenarios consider the supply and demand of the various energy carriers as well as indicate the environmental impact on different future policy choices. It is therefore possible to quantitatively gauge the effects of different energy options, giving planners a tool for objective decision making. The area of research is of interest because there has been no systematic and integrated work done so far on energy planning by local independent personnel. Aspects included in this study are the current state of energy in different sectors, energy policy and previous related work. (International experts, with very little local input, conducted the bulk of the previous studies).

The document presents an overview of the economic and investment policies implemented by the government, and develops scenarios to illustrate the relationship between energy demand and sustainable development. This study further gives recommendations on what the government energy planners could do in the area of energy to initiate overall sustainable development. It also identifies areas that need further research.

1.13 The Structure of the Dissertation

The thesis consists of nine chapters. Chapter one is the background, giving a general description of the country, an overview of the economy, and the state of energy and institutions that deal directly or indirectly with energy. Chapter two covers the review of related literature, and a review of previous studies in energy sectors is provided. Chapter three outlines the objectives, while chapter four covers the problem statement. The fifth chapter describes the methodology employed and explains the instruments used for collecting data. The sixth chapter covers data analysis.

Data collected were used to compute parameters like the specific energy consumption for different products and the energy intensities for different activities. An economic analysis was carried out using major economic parameters; GDP and the contribution of different sectors to the GDP. The data was used to create scenarios, so that energy demand projections could be made. Conclusions and recommendations were made. The major results of the thesis are included in chapter seven. The future energy supply options are presented in chapter eight. Chapter nine, the final chapter, presents major recommendations and conclusions.

CHAPTER TWO
LITERATURE REVIEW

2.0 Introduction

This chapter gives a review of the literature related to the energy sector, with particular reference to Uganda. It presents descriptions of the structure of the economy, the investment climate, sources of energy demand and supply, demand growth rates and forecast and the energy policy for Uganda. The chapter also contains the functional relationship between energy and environment and an evaluation of various energy models.

2.1 The Structure of the Economy

The Ugandan economy is basically agricultural, exhibiting a great predominance of subsistence farming. Agriculture and livestock together were in 1999 estimated to account for 42.3 % of the total Gross Domestic Product (GDP) .[39] In 2001, 62% of the exports were non-traditional. These are exports that include flowers and fish, other than coffee, tea and cotton which were traditional. [40] In 2002, agriculture contributed 39.8 % to the total GDP. [41] Agricultural exports are dominated by coffee, which accounted for 22 percent, with cotton, tobacco and other food crops accounting for 16 percent. [42] Coffee is still the leading export from Uganda.

The high dependence on agriculture implies that Uganda's economy is vulnerable to changes in climate and the international commodity markets. Agriculture contribution to GDP has been decreasing steadily from 55% in the 1990 to about 39.8% in 2002.[43] Although there is a steady increase of industry's contribution to the GDP; it is still very low, at about 10 %. The transport sector contributes about 4.6 % of the GDP. In recent years other exports, notably fish, have increased. There are efforts to diversify Ugandan exports so as to reduce dependence on coffee. With assistance from the World Bank and IMF, various other reforms have been implemented, for over a decade. The reforms have led to considerable economic advancement in Uganda. There were increases in investment, economic stability and GDP growth. However, apart from the average GDP, the state of the Ugandan economy is still below the low human development indicators. This situation is represented in Table 2.1 below.

Table 2.1: The mean indicators for economic development in developing countries 1994 [44]

Indicators	High Human Develop.	Medium Human Develop.	Low Human Develop.	Uganda (1994)	Uganda (1997)
GDP (Average US$ billion)	101.6	46.9	5.4	4	6.0
Agriculture (as % of GDP)	4	14	34	49	43
Industry (as % of GDP)	34	36	24	14	19
Services (as % of GDP)	59	50	42	37	37
Exports (as % of GDP)	32	22	22	8	12
Imports (as % of GDP)	36	25	32	23	27
Per capita Income (US$)	6820	1540	318	260	300

Uganda had attained steady economic development over the last decade Figure 2.1 below shows that there was a steady rise in GDP in the first half of the last decade, before declining in the last half. In this study the GDP and per capita GDP growth rates of 5.5 % and 2.5% per annum have been used respectively.

The Figure shows that the real GDP grew sharply by 10.4 per cent in 1994, up from 5.5 percent [45] during the preceding year. This was attributed mainly to the favourable weather conditions, the coffee boom and the improved investment climate brought about by liberalisation. [46]

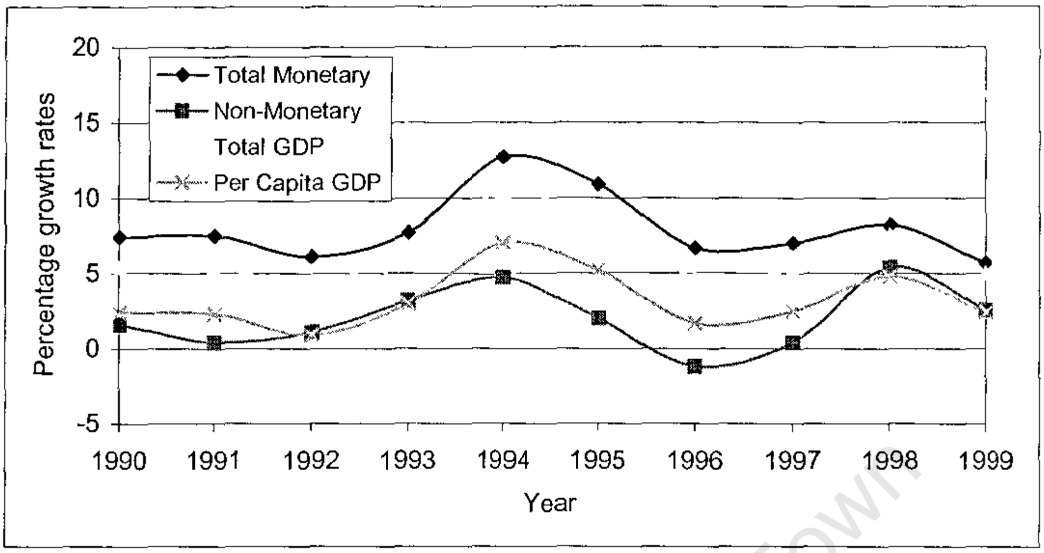

Figure 2.1: Percentage growth rates of GDP and per capita GDP at constant 1991 prices (1990-1999)

There was however a decline in GDP growth rate in the following two years, largely due to the effects of a long drought followed by exceptionally heavy rains. It also coincided with the political instability in neighbouring Rwanda. Further decline in GDP coincided with the political instability in the neighbouring Democratic Republic of Congo. This implies that the future political situation in Democratic Republic of Congo will affect Uganda's economy.

Industrial Production

Uganda's manufacturing sector contribution to GDP is 10 percent, while for most African countries it is above 20 percent. The industry value added in 1999 was 18%, which is lower than low-income countries with value of 30%.[47] The manufacturing sector is also facing challenges from imported goods. From 1990-1997, there was a general increase in the production of manufactured commodities of selected establishments like bricks and cement, steel and food processing. [48]. Figure 2.2 Illustrates the above data.

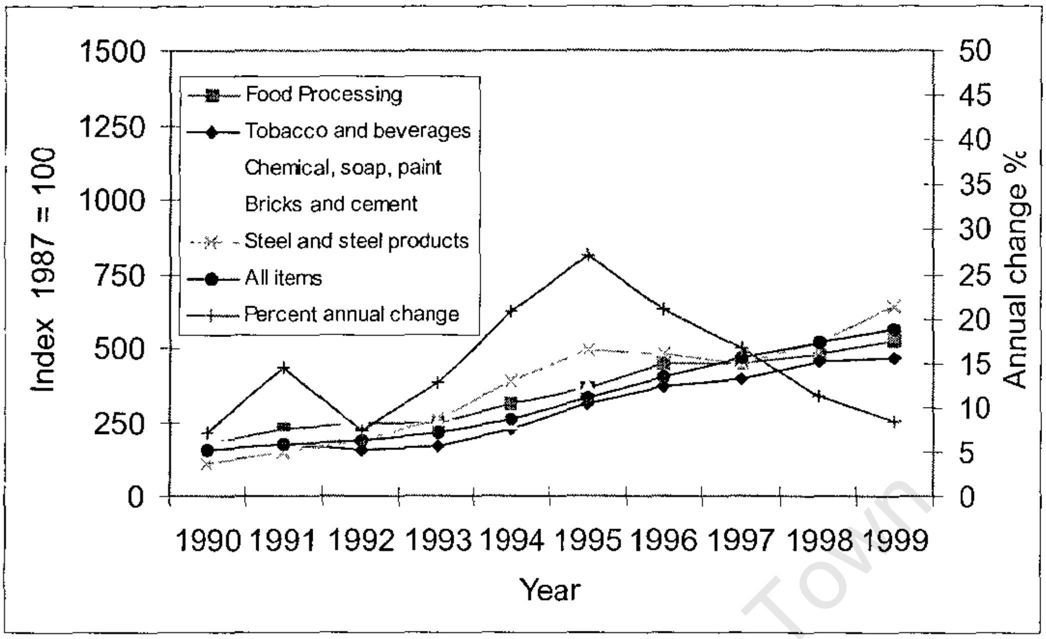

Figure 2.2: Index measure of the level of development in different industrial production (1990-1999)

According to Figure 2.2, the index of industrial production from 1995 to 1999 indicates a decrease in percentage annual change in industrial production. [49] There was an increase in chemicals, soap and paint, with an annual change from 5% in 1990 to 35 % in 1999. The steel and steel products sector increased gradually. The high increase in cement and tiles index indicates that there was rapid growth in the construction industry. The smallest increase was textiles and clothing due to the increase in imported clothing. The industrial production index has decreased from 12.46 % per annum in 1999 to 2.14 % in the 2002 [50].

External trade

Despite the economic progress made during the last decade, the balance of trade is still not favourable. The country is still heavily indebted. In 1998 the external debt was over US$ 3.64 billion.[51] The total exports were still less that 600 million US$ per annum. The debt export ratio was about 733. The Terms of Trade were not favourable for Uganda. The current account balance has been negative over the last decade. Figure 2.3 illustrates the trends of economic development with respect to exports.

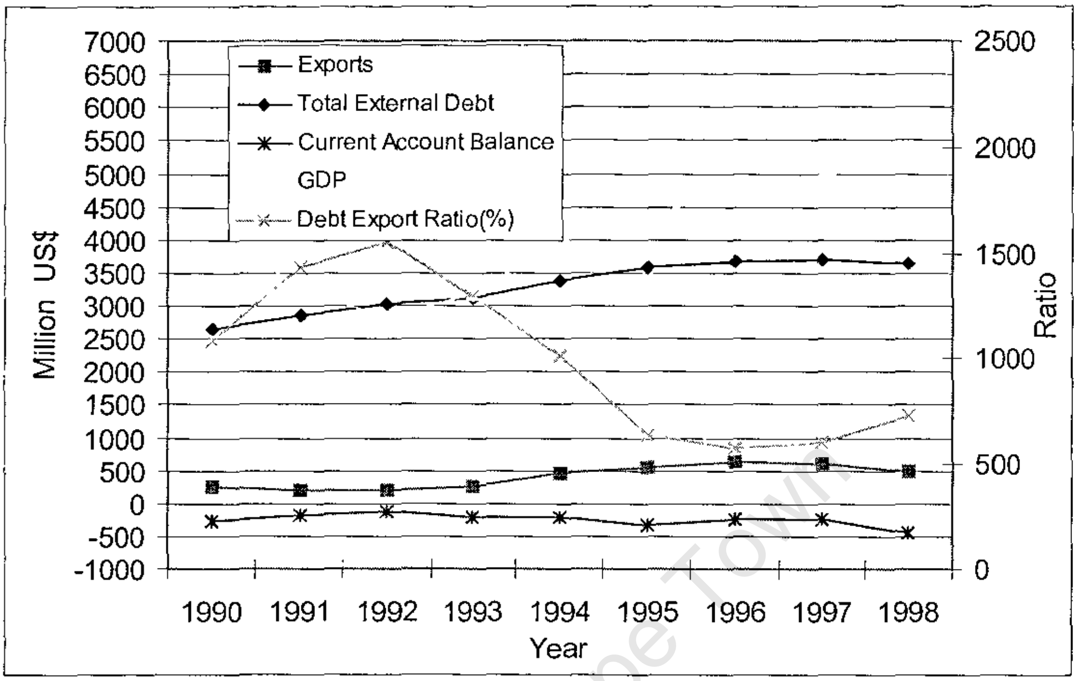

Figure 2.3: Uganda external trade (1990-1998)

Figure 2.3 indicates that pertaining to exports, total external debt, current account balance, GDP and debt export ratio. Uganda will have to depend on loans and assistance from development partners. This also implies that the country has to abide by the rules and procedures set by international financial institutions.

2.2 Sustainable Development

Although a generally accepted definition of development does not exist, there is a broad consensus that it implies increasing social welfare or well-being. In economic terms, development is broadly defined as increasing social welfare. In development economics, social welfare is generally assumed to be positively affected by the economic level and negatively affected by inequality in the distribution of income. [52] Although the term "sustainable development" is open to many different interpretations, there is agreement on the defining principles. There are several definitions of sustainable development. Some are presented below.

Sustainable development would imply economic growth together with the protection of environmental quality, each strengthening the other. But in some cases countries overlook environmental issues and focus primarily on economic development. The essence of this form of development is a stable relationship between human activities and the natural world, which does not diminish the prospects for future generations to enjoy a quality of life at least as good as our own. The absence of sustainable development will lead to over exploitation of our natural resources. [53]

In the context of developing countries, there is a need for more practical approach. The approach must have a stronger emphasis on immediate development objectives such as poverty reduction, local environment, employment generation and economic growth prospects. This would go along way to operationalise sustainable development. [54]

Looked at from the broader perspective sustainable development refers to the need to balance the satisfaction of short-term national economic interests with the protection of the interests of future generations, including their interests in a safe and healthy environment. [55]

Sustainable development can as well be taken as commitment to orderly economic development along with an understanding and respect for the capabilities and limitations of the environment to support growth and economic activity over short or long term. Sustainable developments should not adversely affect people living elsewhere and allow all elements of the community to flourish. [56]

Sustainable development should not be perceived as return to a pre-industrial period, but calls for continued economic prosperity, with business and industry bearing in mind the possible effects of development on the environment. [57]

In the World Commission on Environment and Development 's words: "sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are made consistent with the future as well as present needs".[58] The definition implies that the term sustainable development embraces achieving economic and social development in ways that do not exhaust a country's natural resources.

Sustainable development is also defined as means of meeting the economic, environmental and social needs of today's society without compromising the opportunity of future generation to do the same. In all these three areas, energy plays an essential role. [59]

As can be inferred from the above definitions of sustainable development, there are common principles of sustainable development. These include environmental protection, social advancement, and economic development.

In East Africa, Kenya has proposed indicators for sustainable development and the major ones are: social development indicators which include poverty alleviation and gender equality, environment development indicators looking at both the global and local environment and economic development indicators based on macro/micro economics, energy related-indicators and technology transfer. [60]

Sustainable development criteria for Tanzania were formulated based on existing environmental policy, environmental law, poverty reduction strategy, Tanzania Vision 2025 and public opinion through survey. The criteria focus on maximising flow and retaining of capital and technology transfer to the country. The major indictors for Tanzania are environmental sustainability, social sustainability and economic sustainability. [61]

As for Uganda, the country has experienced a rapid increase in population in Uganda. As a result, there is increasing pressure on woodlands, forests and wetlands. The use of woodland and forests has intensified particularly on two fronts. One is the increased conversion of woodlands and forests for agricultural use to accommodate the growing population. The other is the development of the construction sector where the demand for timber and firewood for burning bricks has increased. In addition, there is a heavy dependence on biomass resources in households. Efforts to introduce country-wide electrification have met with little success so far. Consequently, the quality and quantity of resources on which sustainable development depends is declining. Hence, Uganda is in the process of developing sustainable development criteria. Typically, economic development, social development and environmental protection are seen as interdependent elements of sustainable development. [62]

There are basic criteria for issues surrounding suitability. Herman Daly's is an example. In Herman Daly's criteria for sustainability, the following items are considered as important: [63]

- Renewable resources must be harvested at or below the yield rate.
- Non renewable resources are being depleted, it calls for development of renewable energy to act as alternative source of energy.
- Even though the world cannot be free of pollution emission, it should be controlled at level at which the environment can accommodate.

2.3 Biomass Energy Resources : Fuelwood

The National Biomass Study, the first detailed study conducted in Uganda, targeted urban areas and larger wood consumption areas where the demand outstrips supply, such as Mbarara, Kampala, Kabale, Mbale and Arua districts.[64] Over-exploitation of wood resources in these areas has lead to excessive deforestation. Uganda was stratified into twelve land cover / land use areas. The vegetation coverage for each land type is shown in Table 2.2.

Table 2.2: Areas and distribution of land cover/land use at national level [65]

Class	Land type	Hectares
1	Plantation and wood lots-deciduous trees/broad leaves(hardwood)	18,682
2	Plantation and wood lots-coniferous trees/broad leaves(softwood)	16,384
3	Tropical high forest- normally stocked.	650,150
4	Tropical high forest- depleted /encroached	274,058
5	Woodland- tree and shrubs, thickets.	5,396,497
6	Grassland, range lands, pasture lands, open savannah.	5,115,266
7	Wetlands vegetation, swamp areas, papyrus.	484,037
8	Subsistence (mixed farm land, agricultural fallow areas.)	8,400,999
9	Uniform mono-cropped (non-seasonal farm land- e.g. tea and sugar estates)	68,446
10	Water	3,690,254
11	Built up areas (urban and rural)	36,571
12	Impediment areas bare rock, barren soil.	3,713
	Total	24,155,057

The Woody Biomass Study indicated that at least 270 Peta Joules [66] (30 million cubic meters of solid wood) is generated in Uganda each year. Total woody biomass for production of charcoal, commercial firewood and collected woodfuel has been estimated at 257.4 Peta Joules (28.6 million cubic meters solid wood). [67]

According to the ESD study team, woodfuel provides rural households with nearly 150 Peta Joules [68] (10 million metric tonnes) of their primary energy needs. It also provided for small-scale and larger scale economic activities at an annual consumption of 19.5 Peta Joules [69] (1.3 million metric tonnes) in 1994. The wood fuel demand in small-scale industries is growing as fast as the construction industry at a rate of 20 % per annum.[70]

Based on the production of 33 million tonnes [71] and an annual consumption of about 24 million tonnes, Uganda is expected to have a net balance of about 9 million tonnes [72] of air-dry tonnes annually. However, net change analysis indicates that Uganda is loosing close to 12 million tonnes [73] of wood stock annually implying that 21 million tonnes[74]of wood is unaccounted for. This loss is attributed to wood that is cut and left to waste as the land is cleared for agricultural purposes.

2.3.1 Fuel wood Consumption

A number of studies give estimates for the overall national woodfuel consumption in Uganda. The estimated consumption of wood in 1986 was 164.7 Peta Joules (18.3 million cubic meters) per annum and it was expected to rise to 247.5 Peta Joules (27.5 million cubic meters) in the year 2000.[75]

A joint UNDP /World Bank [76] study estimated the per capita Ugandan woodfuel requirement in 1990 to be about 12.6 Giga Joules per capita. [77] In 1992, the per capita consumption of fuelwood was estimated to be 11.25 Giga Joules.[78]

Table 2.3 : Final energy demand (effectively utilised energy) 1994 (in Peta Joules) [79]

Sector	Biomass	Petroleum	Electricity	Total	Percentage
1.Household					
-Urban	3.3	0.1	0.9	4.3	2.8 %
-Rural	130.7	0.3	0.01	131.1	85.0%
Sub Total	134.0	0.4	0.91	135.4	87.8 %
2. Industrial	7.1	0.9	1.2	9.2	6.0 %
3. Commercial	4.3	0.5	0.6	5.4	3.5 %
4. Institutional	3.4	0.2	0.3	3.8	2.5 %
5.Transport	0.0	0.4	0.0	0.4	0.2%
Sub- Total	14.8	2.0	2.1	18.8	12.2%
Total	148.8	2.4	3.0	154.2	100%
Percentage	96.5 %	1.5%	2.0 %	100 %	

Table 2.3 shows the dependency of the different sectors on different energy sources. Most of the energy was used in the domestic sector. Biomass was the most common source of energy for all sectors except the transport sector. Petroleum is mostly used in the transport, industrial and commercial sectors.

The consumption of wood products, mainly sawn timber, charcoal and firewood was estimated in 1995 to be 20 million tonnes.[80] It was estimated that the growth rate is about 3.6 % per annum,[81] and the projection revealed that consumption of wood products would almost triple from 20 to about 60 million tonnes by 2025.[82] The estimated sustainable yield is 21.1 million tonnes, which shows that Uganda's consumption of wood products is not sustainable. [83] In 1999, it was estimated that 64.3% [84] of the wood products was used by households. This study covers the estimated wood energy demand for all other sectors, excluding sawn timber and poles.

Wood consumption has over the years been estimated by a number of international agencies. There are several studies that have made estimates for wood consumption in Uganda as shown in Table 2.4 below. Most of the studies were done by the World Bank. Apart from the Biomass Study, these estimates were based on various internationally available figures based on studies conducted within Uganda.

Table 2.4: Fuelwood consumption estimates (Peta Joules)

Study	Consumption	Annual sustainable yield
UNDP/World Bank (1983)	179.7	170.95
ESMAP (1996)	238.6	342.5
EC-Woody Biomass (1996)	148.8	
National Biomass Study Phase I (1991)		396
National Biomass Study Phase II (1995)	224-238	336
National Biomass (2002)	390	301.5

In 1982, it was estimated that the annual consumption of woody biomass for fuelwood was higher than the sustainable yield. In the biomass study, the total available woody biomass growing in a year was still higher that annual consumption. Different studies use different conversion factors for wood to energy. The official estimates for land clearing varies from 70,000 hectares to 200,000 [85] while the Biomass Study phase II estimate is slightly over 200,000 hectares per annum. [86]

The Household Energy Planning Program (HEPP) [87] was initially expected to come up with highly reliable and detailed information on wood fuel consumption in various parts of Uganda. The methodology and results of the Consultant CODA and Partners report have been very heavily criticised by the Ministry of Natural Resources. As a result, the report was discarded as the basis for government policy in this area. Among the reasons given by the Ministry of Natural Resources were that the number of people interviewed in the urban and rural areas was too small to present a fair sample for Uganda.

In the household energy surveys, 450 urban and 159 rural households were interviewed. [88] Average per capita firewood consumption in the urban areas was estimated at 218.7 kg per annum. The average per capita charcoal consumption was 279.1 kg per annum. Per capita wood fuel consumption in the rural areas was 288 kg per annum. The results suggested that annual urban and rural consumption levels of firewood were 3.28 Giga Joules and 4.32 Giga Joules respectively. [89]

Energy Demand Growth Rates

Various studies carried by the ESMAP gives annual energy demand growth rates which are used in energy models for the purpose of energy forecast. Such an example is provided in Table 2.5.

Table 2.5: Energy demand forecast (% annual growth rates, Base Case) [90]

	1990-1995	1996-2005	1990-2005	1992-2012
Total Energy Demand	3.0	3.0	3.0	3.0
Electricity	8.0	6.2	6.8	6.3
Petroleum	2.1	6.8	5.2	6.9
Wood fuel	2.9	2.9	2.9	2.9

As shown in Table 2.5 above, annual total energy demand growth is just about the same as the population growth rate. The increasing rate in wood fuel demand indicates that there would not be a major shift to other forms of energy. There are high annual growth rates in petroleum and electricity. This implies that there will be a growing need for commercial energy in the transport and industrial sectors. Consider Table 2.6.

Table 2.6: Energy demand growth rates and consumption scenario, (Peta Joules) [91]

Sources of Energy	Growth Rates	1995 (base)	2005	2015
Firewood	3.5 % per annum	176.4	248.8	351.0
Charcoal	7 % per annum	12.0	23.6	46.4
Petroleum	8 % per annum	14.5	31.4	67.8
Electricity	3.5 % per annum	1.8	7.2	19.8
Total Energy Use		204.7	311.0	485.0

Table 2.6 gives energy scenarios developed by the Biomass Study. The data were extrapolated from the 1995 figures for the following 20 years. The firewood was aggregated from commercial and non-commercial components.

The forecast in biomass demand for energy was made in 1995, [92] projected up the year 2012. The consumption of wood products (mainly sawn timber, charcoal, and firewood) was estimated to be 20 million tonnes in 1995, with an estimated growth rate of 3.6 % in the consumption of wood products. The projection revealed that the consumption of wood products would triple from 20 million tonnes to about 60 million tonnes by the year 2025. [93]. The biomass consumption by different sectors is presented in Table 2.7.

Table 2.7: Total Biomass Production for Wood fuel in 1994 (Peta Joules) [94]

Demand	Charcoal	Wood (Commercial)	Wood (Collected)	Total Wood Biomass
1. Household				
- Urban	8.111	0. 49	8.530	16.690
- Rural	0.492	0.23	13.0169	130.684
Sub-total Household	8.603	0.72	138.699	147.374
2.Industrail				
- Tea	0	0.210	0	0. 210
- Lime	0	9.696	0	9.696
- Tobacco	0	0.938	0	0. 938
- Sugar / Jaggaries	0	1.426	0	1.426
- Brick and Tiles	0	3.443	0	3.443
- Fish	0	3.507	0	3.507
Sub-total Industrial	0	19. 220	0	19. 220
3. Commercial				
-Hotel, Restaurant, and Bars.	2. 989	2. 874	0	5. 863
- Bakeries	0	0. 465	0	0.465
- Breweries	0	1. 109	7. 031	8. 140
Sub- total Commercial	2. 989	4. 448	7. 031	14. 468
4. Institutional				
- Schools	0.45	1. 072	0	1. 117
- Prisons	0.90	0.119	0	0. 209
- Hospitals	0.75	0.123	0	0. 198
Sub- total Institutional	0.210	1. 314	0	1. 524
Total	11. 804	25. 054	145. 730	182. 586

It is estimated that over 94% of the total wood biomass was collected freely from the forests and bush. The industrial sector depends on commercially available wood fuel. The commercial sector meets most of its requirements from commercial wood fuel with the exception of small-scale breweries that collect about 86% of their fuel wood needs. Institutions meet most of their demand from commercially available wood fuel. Charcoal is the most poplar biomass fuel in the urban household, as shown in Figure 2.4.

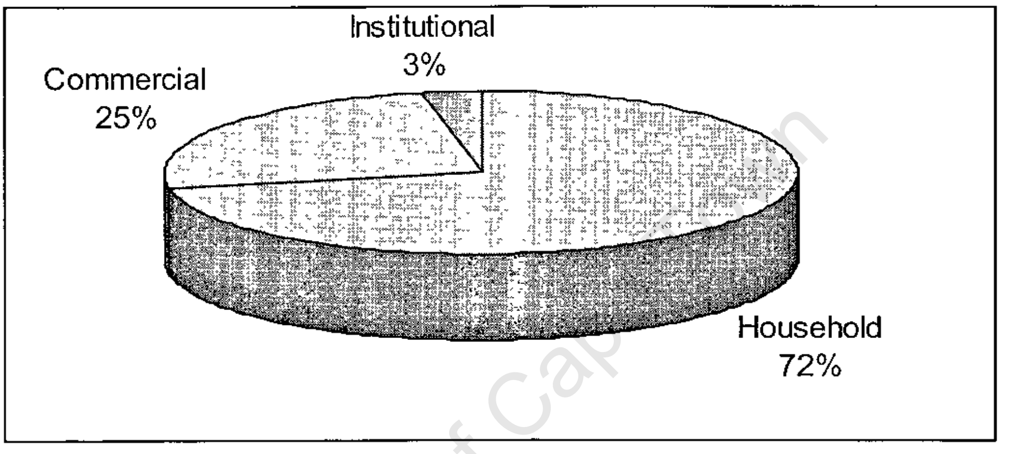

Figure 2.4: Charcoal consumption in 1994 [95]

Figure 2.4 illustrates that the domestic sector was the largest consumer of charcoal. It was mostly used in the urban domestic sector. Hotels, restaurants and bars used about 25%, while institutions utilised the rest.

In the ESD Study, it was estimated that 15% [96] of the urban households consumed wood fuel as their primary fuel. Their consumption was estimated to be the same as that of the rural households, which is 9.105 Giga Joules per capita. This is close to other rural surveys for the region, which show rural per capita energy consumption of the order of 7.5 - 11.5 Giga Joule. This implies that urban households consumed some 21 Peta Joules of wood fuel in 1994. [97]

Furthermore, the ESD Study estimated that 90 % [98] of the rural households freely collect their wood fuel while 10% purchase wood for household purposes. Rural household consumption of wood is in the order of 148 Peta Joules, of which an estimated 117 Peta Joules is freely collected .[99]. It was noted that the woody biomass demand for urban and rural areas has been increasing at a rate of over 3% per annum or about 6 Peta Joules. An estimated 52.5 Peta Joules of wood was commercially sold and over one third of the amount that is over 46.5 Peta Joules, was consumed by the industrial sector. [100]

Fuel wood

A study carried out in Botswana showed that woodfuel was mainly collected from the dead wood which is largely a by product of other activities like land clearing for pasture, agriculture and timber harvest.[101] Fuelwood collection is not the main cause of deforestation but it is excessive harvesting trees beyond suitable yield.

The partners in development assumed that fuelwood crises in developing countries are due to supply and demand of this crucial energy source. As the result over the last decades hundreds of millions of dollars were committed to policy, planning and aid structures to meet biomass energy demand. [102]

Bearing in mind that the problems will be solved by increasing biomass supply, the Ministries and their department responsible for energy supply tried to increase supply by peri-urban plantations and village woodlots. The Ministry of Energy spearheaded promotion of efficient stoves to reduce energy consumption and use of efficient charcoal kiln to reduce pressure on forests. However, with low level of electrification and rising cost of fossil fuels, it is a great challenge to promote the use of petroleum products and electricity instead of fuelwood .[103]

As a mater of fact, the Ministries responsible for energy decided to use top-down and over-specialised donor driven approaches to solve the fuelwood problems. But they failed to notice that rural and urban people, in spite of their limited resources, were responding to fuelwood crisis though imaginative, innovative and with far lower cost than most project interventions. [104]

But that is not to suggest that there is no simple answer to fuelwood supply. The solution lies in and a multi-dimensional approach. It should be noted that there are other underlying factors such as population growth rates, poverty, land and resource management. All these point to the recognition that the solutions to fuelwood crisis should be solved as integral part of other related problems. [105]

In order to implement successful projects, or other types of intervention, there are some basic factors that must considered namely: [106]

1. The initial approach should be an understanding of the main causes of problem. That can be done by detailed local assessment of the target social group. The suggested solutions should be site specific.
2. The participation of local people in all stages of project related to fuelwood issues, so that they can feel that they are part of the solution to the problem.
3. Mobilisation of social groups and implementation of decentralised and multi-disciplinary approaches will make it possible to solve fuelwood problems.

In addition, the population growth rates and subsequent population density is a significant factor that can have effect on range of variables. Thus, increasing population density forces community to change land use and management. The available land can then be used optimally and biomass resources given higher consideration. As the result woody biomass instead of declining can increase. [107]

One of other effects of increased pressure on land and population density is not only that, apart from the increases on quantity of on-farm woody biomass, but also its type changes. Furthermore, increased population density has forced the society to use marginal land to be used more effectively and any other vegetations to be replaced with well managed woody biomass. [108]

Interestingly, mixed results were obtained from an on-farm woody survey in Kakamega District which showed that, as opposed to the first assumptions of the Kenya Fuel Wood Project, that were was increased in the quantity of biomass as the population increases because of changes in agriculture practice. Although there was increase in the woody biomass, the amount of biomass available per person actually decreases with increasing population density. [109]

Other various studies were conducted in a number of developing countries which indicated that households can adapt to fuel scarcity depending on the socio-economic status of the household. The household may spend more time for firewood collection; reduce amount of cooked meals per day or use of alternative fuel in the most cases low quality fuels such as agricultural residue. [110]

In some countries like India, the government introduced innovative method of joint forest management and forest policy reform. In a study made by the World Bank, for example, some 40,000 village communities were then protecting about 4.5 million hectares of forest. Some of the innovative methods include a wide range of land lease or land sharing arrangements, in collaboration with the state forest department. [111]

The introduction of a new policy process in India which was initiated in 1988, treated people as a solution to the problem and not as source of problems. Formal plantations were introduced to be the main source for timber and pulp as opposed to individual firm. The forests were well managed and maintained for their environmental and ecological benefit and to meet the minimum need of local people for woodfuel and other forest products. These policies led to stablisation of the Indian forest area and possibility increasing.[112]

As opposed to most of the African countries, the deforestation in India was not due to the extension of agricultural land or forest encouragement. There was national policy that allowed importation of timber from other countries; plantations of prosopis juliflora; success in joint management and success in farm forestry. These two factors led to increased fuelwood supply in India. [113]

Biomass is considered to be renewable source of energy. Most of the fuels used from forest are from dead trees, cuttings and prunings. In many other areas, wood fuel originates from the biomass produced by land clearing operations to transform forests and wood lands into agricultural farms and pasture. In this case wood is used fuel wood or is made into charcoal. Trees planted in the marginal lands and farming land through agro forest schemes are important sources of woodfuel. [114]

It is now widely accepted that the old perception that firewood and charcoal are a major cause of deforestation is no longer holding. The main culprits are agricultural and forest activities. In countries where there are subsidies to the conventional energy sectors are directly hampering the proper development of more sustainable wood energy systems.[115] In most countries the subsidies have been lifted and consumers are paying the real price. This will encourage development of sustainable use of woodfuel.

However, of recent in many countries wood fuel consumption is so great that it exceeds its sustainable yield from available and accessible supply sources, it is coupled with use of inefficient charcoal kilns. That leads to many countries facing fuel wood and charcoal shortages and depleting wood stocks.[116]

Deforestation

In Uganda, the average annual deforestation for the period 1990 to 2000 was estimated at 2% per annum, which is an equivalent to 913 square kilometres per annum. It is very high when compared with low income countries which have deforestation rates of 0.7 % per annum. The neighbouring countries such as Kenya and Tanzania the deforestation rates are 0.5 % and 0.2 % respectively.[117]

2.3.2 Improved Stoves

Over the last two decades, the issues related to environmental degradation due to loss of tree cover, which is the main source of fuelwood and charcoal, were a major concern worldwide. Consequently improved household wood and charcoal stoves programmes were launched. The main objective was to reduce energy demand thus saving trees [118].

The use of stoves particularly in poorly ventilated house can be a source of health problems. It implies that use of improved charcoal and wood stoves will reduce the amount of smoke in the households. Many of these programme failed because, it was top-down approaches and the participation of the private sectors were minimal. And yet it is the private sector who can understand market related issues such as consumer taste and market dynamics.[119]

The Poverty Impacts of Fuel Substitution on Traditional Fuel Suppliers project was carried out in three countries namely Kenya, Ethiopia and Uganda. The result can be summarised as follows: [120]

- Both in Kenya and Ethiopia, the people who were involved in the production of stoves were very successful. As the result there was improvement in their incomes and hence poverty alleviation. The entrepreneurs were able to sustain their business without continued government and partners in development support.
- The high and medium classes in Kenya and Ethiopia have more disposable income and consequently have shares in the stove market, unlike in Uganda where most of the customers are of low income households.
- The targeting of middle and upper class households consumers in Kenya and Ethiopia, assisted the entrepreneurs to improve of their cash flow that led to the initial success of commercial production of stoves.
- The study shows that, at initial stages government and partners in development backing is crucial. The consultative approach in identifying the roles of the government, the partners in development and the stove producers is very important.

2.3.3 Stove Testing

There are a number of foreign and local organisations that have tested the efficiency of domestic charcoal stoves. Similar tests have been conducted in different universities and other institutions.[121, 122] There are three common methods used in stove testing namely; water boiling tests, controlled cooking tests and kitchen performance tests.[123] Stove tests were carried out at the Appropriate Technology Centre of Kenyatta University.[124] The

Table 2.9: Wood energy consumption in Ugandan industries in 1994 [126]

Industry	Tonnes	Peta Joules	% Total
Lime	646,000	9.696	54.7
Bricks and Tiles	230,000	3.443	19.4
Fish	234,000	2.004	11.3
Sugar / Jaggeries	95,000	1.426	8.0
Tobacco	63,000	0.938	5.3
Tea	31,000	0.210	1.2
Sub-Total	1,299,000	17.717	100.0%

As shown in Table 2.9, the lime industry is the largest consumer of fuelwood, followed by bricks and tiles. Lime and bricks are mostly used in the construction industry. Table 2.10 presents end products in the selected countries in Africa and South America.

Table 2.10 : End products produced by 100 kg of wood [127]

Country	Amount of end products produced	Specific fuel consumption (kg wood/kg product)
Malawi	Cures 6 kg of tobacco	16
Tanzania	Cures 38 kg of green tea leaves	2.6
Ivory Cost	Smokes 66 kg of fish	1.5
Guatemala	Bakes 50 kg of bread.	2
Burkina Faso	Brews 100 litres of traditional beer	1

The above Table 2.10 gives the amount of end products produced by 100 kg of wood and estimated specific energy consumption for different products from selected African countries and South America. The specific fuel consumption for curing of tobacco was very high compared with other products listed.

Lime Burning

Lime in Uganda is produced by small and medium scale industries often using energy inefficient means. Most of the lime producers are in Tororo and Kasese districts. Wood requirements per kilogram of lime produced are greater than 3 kg of wood to 1 kg of lime in open lime stacks. The producers using vertical shaft kilns use 0.3 Giga Joules (2 kg) of wood to produce one kilogram of lime.[128]

An average of 30 MJ of wood is used for each kg of lime produced as opposed to 15 MJ of wood to 4 or 5 kg of lime in energy-efficient kilns.[129] This makes lime burning one of the main consumers of fuel wood. It accounted for nearly 646,000 tons in 1994,[130] given the inefficient production methods.

Lime production in a Tororo Clamp kiln is not efficient, with firewood utilisation of 1 kg for 0.80 kg of quick lime produced. Generally the kiln designs are of low efficiency. The crucial design parameter of height to diameter ratio should be 6 as opposed to 1.9 in most common kilns.[131] The major constraint to construction of efficient kilns is the higher capital cost; thus operators opt for the short kiln with large diameters. Use of drier firewood would improve firewood utilisation by about 12%. The lime production has a low yield of about 62%, leading to further wastage of fuel, as unburned limestone is recycled. [132]

Tobacco Curing

Small-scale farmers do all the tobacco growing and curing in Uganda. Tobacco farmers are major users of fuelwood for curing their tobacco. This has historically had a destructive impact on natural woodlands in the Arua district. In 1999, British American Tobacco Uganda (BAT) started a large afforestation programme, which aims at providing firewood for the majority of their farmers. BAT has inventoried 23 million trees now growing at farmer's wood lots or plantations.[133]

Over 16,000 rural Ugandans cure tobacco in over 9,600 barns using fuelwood. Is it estimated that there are about 20,000 barns in the West Nile region. [134] Approximately half of these farmers use the energy inefficient flue-curing method. The improved Malakisi barn (an improved barn developed in Malawi) was introduced in 1989. The tobacco grown in the Mubende/Bunyoro area is fire-cured.

Currently, there is a drive by British American Tobacco to cut down the fuel usage in the tobacco curing areas by improving the types of barn with lower specific energy consumption. The most efficient tobacco barn is the *venturi barn* (developed in Brazil) with a specific fuel consumption of 3 to 4 kilograms of wood per kilogram of cured tobacco. This type of barn is being disseminated to the Kigezi regions and especially in Rukungiri. In this study, an average specific energy consumption of 3.5 was used to estimate energy consumption of flue cured tobacco. [135]

Jaggeries

In 1994, there were at least 39 small-scale sugar jaggeries that produced between 15-20% of the sugar consumed in Uganda.[136] These Jaggaries utilise wood almost exclusively to refine the cane to "jaggery" (a relatively inferior form of sugar, somewhat between molasses and unrefined castor sugar) as they lack facilities to handle and burn bagasse. Jaggery is produced over an open fire. The energy efficiencies are very low. Nearly 1.5 Peta Joules of wood are consumed annually in this sub-sector. No studies have been carried out to improve the efficiency of these jaggeries.[137] The recent activities are addressed in section 6.7 of this study.

Fish Smoking

An estimated 40% of all the fish is smoked before being transported to market. Most of the fish is smoked using open fires. An estimated 2 Peta Joules [138] of wood was bought and consumed in Uganda in 1994 for this purpose. Not much work has been done to improve efficiencies. It is estimated that 2 kg of fuelwood is used to dry one kg of fish. [139] The estimate is similar to the data given for drying fish in Burkino Faso. The amount of fish smoked is decreasing because there is an increasing number of fish processing plants in Uganda, that are targeting the export market.

Bricks and Tiles

Brick and tile production is generally on a small scale. In 1994, these industries consumed about 3.443 Peta Joules of woodfuel.[140] Like their counter parts, the brick and tiles use inefficient kiln. Yet, correspondingly, as construction industries grows, the wood fuel consumption will increase. This study established that there was not much difference in types of kiln used in brick and tile production in the informal sector. It is the three large-scale brick and tile producers, namely: Kajansi Clay Works, Allied Clay Works and Clay and Tiles Products who use coffee husks as their main source of fuel.

Commercial Sector

Charcoal and firewood are widely used in the commercial sectors in bars, hotels, local traditional breweries and bakeries. Hotels, bars and restaurants are the largest consumers of biomass as shown in Table 2.11 below.

Table 2.11: Estimated commercial woody biomass consumption in 1994 [141]

Commercial Establishment	Charcoal (TJ)	Charcoal ('000 tons)	Wood (TJ)	Wood ('000 tons)
Breweries and distilleries	0	0	1,109	74
Hotels, restaurants, bar	2,989	100	2,874	192
Bakeries	0	0	465	31
Total	2,989	100	4,448	297

2.3.5 Charcoal Production

Traditional kilns such as the long Kinyakore Kiln and the pit kiln are the most dominant among the charcoal burners in Uganda. Improved kilns were introduced in the 1960's and 70's with some success, but the development was retarded during the period of political strife in Uganda.

For instance, a survey of kiln efficiency in Nebbi district in 1985/86 yielded an average conversion efficiency (by weight) of around 10% .[142] The Forest Department estimates a conversion efficiency by dry weight of 10-15%,[143] while it was estimated that the conversion efficiency by weight is 15%. The estimate was based on visiting a large number of charcoal kiln sites in the area. [144]

The Household Energy Planning Programme (HEPP) [145] report asserts that the pit kiln has a low conversion efficiency ranging between 7% and 15%, and the report uses 10% in its calculations. Ugandan charcoal burners normally use almost fresh wood. The reasons are that the operators are impatient, with no understanding of the relationship between dryness and conversion efficiency. The raw material is normally free and the operators find the kiln difficult to operate.[146]

It was estimated that 1.596 million tons of wood was used to produce 200,000 tons of charcoal in 1991. This indicates conversion efficiency by weight of 12.5 %.[147] The earth clamp kiln operated at efficiencies as low as 8.5%. In 1993, it was reported that 1.178 million tons of wood was converted into charcoal but the yield of charcoal was a mere 0.27 tons as opposed to 0.5-0.7 if better kilns had been used. [148]

The largest production of charcoal for urban households is obtained from savannah woodland and semi-arid zones. This charcoal is preferred because of its high density. These zones have an annual yield of woody biomass, from trees and bushes, of about 2.01 tonnes / ha (3.14 m^3 /ha). The corresponding land required by charcoal producers to produce 2.45 m^3 of solid wood for charcoal production per hectare from these zones is about 0.78 ha per annum.[149] An improvement in charcoal production efficiency from 10% to 25% would reduce land clearing for charcoal production from 0.78 to 0.312 per hectare per annum. [150] In this study, it assumed that charcoal kiln efficiency is 12 %. The data referred to in the preceding statement is presented in Table 2.12.

Table 2.12: Charcoal production efficiency versus wood consumption [151]

Kiln Efficiency	Annual Wood Equivalent Consumption (m^3)	Land Area Equivalent (ha)	Annual WE Saving (%)
10 %	2.45	0.78	Base
15 %	1.63	0.52	33.5 %
20 %	1.26	0.39	49.8 %
25 %	0.98	0.31	60.0 %
30 %	0.82	0.26	66.5 %

Table 2.12, above, illustrates the relationship between the production, efficiency and amount of wood necessary with the equivalent land required for such production. Land clearing can be reduced if efficient kilns were used. There would be a reduction in wood equivalent consumption.

The estimated efficiency of the modified "*casamance* " kiln used in Uganda is 12.5%. [152] For the traditional kiln the efficiency is as low as 10 -12 % on a weight basis. In 1999 MAB-CASA kilns were introduced in the charcoal production areas of Luwero, Masindi and Nakasongola Districts. It is similar to the casement kiln, but it is covered with metal to control the carbonisation process. These kilns have a charcoal yielding efficiency ranging between 30 and 35 per cent. It is better than the traditional kiln whose yield efficiency is 10 to 15 percent and the Mark V steel kiln with an efficiency of 15-20 per cent. [153]

2.3.6 Charcoal Consumption

According to the HEPP 's kitchen tests, the average charcoal consumption in the urban areas was 4.7 Giga Joules (156.7 kg) per capita per annum. [154] The National Biomass Study found that the average per capita charcoal consumption in the urban areas was about 4.5 Giga Joules (150 kg), [155]as shown in the table below.

Table 2.13 : Estimates of proportions of households using charcoal in 1994 [156]

Category	Household use %
Charcoal Rural	2.7
Charcoal overall urban	54.9
Charcoal Kampala	88.4
Charcoal Jinja	84.0
Charcoal Entebbe	86.0

Charcoal is the dominant source of energy in the urban areas as illustrated in Table 2.13. The use of charcoal in rural areas is less than 3%. The HEPP [157] report estimated that 0.3 Giga Joules of charcoal is equivalent to 2.4 kWh, with stoves used in Uganda. 300 GWh used in households was equivalent to about 3.75 Peta Joules of charcoal or a little over half of the charcoal production in 1994.

In 1994 nearly 12 Peta Joules [158] of charcoal were produced and marketed in Uganda. This figure is nearly double the official estimates. The urban household demand was estimated at 8.4 Peta Joules while commercial establishment demand was estimated at 1.5 Peta Joules. Thus the consumption for household and commercial establishments was estimated at about 20 % and 25 % of the total charcoal production. Charcoal is the most important fuel in the urban areas and the consumption is increasing at rate of 6.5% per annum. [159]

A study carried out by ESD in 1994 revealed that the charcoal inflow into Kampala was over 3.0 Peta Joules per annum. That is over 50% of the charcoal produced in the country [160]. ESMAP's household demand survey in 1994 showed that the per capita usage of charcoal in Kampala was 5.7 Giga Joules, [161] while the ESD study, the estimate was 6 Giga Joules. This is equivalent to an urban household charcoal consumption of between 7.5 and 9.3 Peta Joules per annum. The national estimate was about 8.1 Peta Joules per annum in 1994. [162] The results of the most recent survey, which was conducted by the reasecher, is included in Chapter 6.

From the study made by the World Bank, the projected consumption forecast total of round wood would be 25.658 million tonnes by year 2012.[163] On the other hand, a household survey conducted during the World Bank Energy Sector Management Assistance Programme mission in February 1995 estimated that 15 % of the households in Kampala and Jinja owned improved stoves. [164] This implies that most of the households are using traditional metal stoves. It was assumed that 25% of the household would be using improved stoves to reduce the charcoal consumption by 35% by the year 2005. [165] The projected growth rate of the population was 2.5 % per annum. It was further assumed that the energy demand for fuelwood would remain constant at 2.9 % per annum for the period 1990-2012.[166] The forestry department estimates for fuelwood for 2000 was 23.129 million tonnes of round wood. [167]All these forecast have implication to the energy supply and demand in Uganda.

2.3.7 Agriculture Residue

In the rural community, farm wastes are used as fuel. In the commercial sector, coffee husks have become an important source of fuel for the brick making industry. Bagasse is commonly used for cogeneration in sugar factories. On average, the stock of biomass in nine selected districts for tree biomass and bush biomass was 10.99 tonnes and 2.37 tonnes air dried weight per hectare respectively, while agricultural residues was 1.03 tonnes, giving an overall average of 14.40 tonnes per hectare. [168] It was estimated that in 1995, about 1.73 million tonnes of agricultural waste was available for energy. [169]

Coffee Husks

Coffee is harvested twice in a year producing an average of 0.8 tonnes per hectare of air dry berries per harvest, comprising 50% pure beans and 50% husks. The amount applies to Robusta Coffee. Arabica Coffee has a corresponding yield of 0.35 tonnes per hectare.[170] Most of the coffee husks from Robusta Coffee are used in farms and little in brick burning.

In 1994, Uganda exported over 160,000 tonnes of processed coffee yielding about 180,000 tonnes of waste that could be used for other purposes including briquetting. This quantity could form about 40 % of the fuelwood used in the country to produce charcoal, according to the Uganda National Energy Development Organisation. [171]

However removing too much of these residues would deplete the soil and might thus contribute to land degradation. The use of briquettes in Uganda is negligible due to poor technology especially with respect to binders and poor marketing of the product.

Coffee husks can be used to generate electricity. It is estimated that 18,000 tonnes of coffee husks could generate 30 GWh [172] of electricity annually, if appropriate technology was used.

Electricity by Biomass

There is an ongoing initiative to produce electricity from biomass in the West Nile Region. One of the proposals was to install coffee husk gasification / diesel based generation facility at Paida. The main source of raw materials would be coffee husks. There is a need to estimate the availability of coffee husks to support the gasifier, since coffee growing is seasonal. [173]

Rice Husks

In 1996, Uganda produced 28,000 tonnes of rice, yielding over 15,000 tonnes of rice husks.[174] The amount of rice husks available is insufficient to generate electricity on a sustainable basis, therefore it was not considered as an alternative source of energy for electricity generation. Most of the rice mills are concentrated around townships. The mills generate considerable quantities of husks, which pose problems of disposal. Often rice husks are burnt in-situ, thus posing environmental problems.

Sawmills Wood Residue

Uganda has a number of sawmills and wood processing facilities. There is therefore a potential for sawmills to generate their own electricity. At present, sawmills are so dispersed and at such a low level of technology, that there is little likelihood for production of electricity from wood waste in the foreseeable future. The average capacity utilisation of sawmills in Uganda is 30%, the sawmill production is over 197,900 cubic meters of wood waste a year. [175]

Using biomass for electricity generation has financial and technical hurdles to overcome, before it could be used for rural electrification. Most of the small-scale farmers and businessmen have little expertise and capital to convert the wastes to generate electricity. Moreover, most of these enterprises rely on old diesel-driven generator sets for their power supply.

2.4 Hydropower Resources

Uganda is well endowed with a hydroelectric potential estimated at 2,000 MW, [176] mostly located between Lake Victoria and Lake Kyoga, and between Lake Kyoga and Lake Albert. The list of major sites and their potential is included in Appendix B Table B2.1. In addition, the potential of mini/micro hydropower is over 70MW as shown in Appendix B Table B2.2.

The existing installed generating capacity in the country is 318 MW and an additional 80 MW is under development at Kiira Hydropower Station.[177] In addition, the Uganda Electricity Generation Company operates a 1 MW mini hydropower plant at Kabale, and about 2 MW of isolated diesel-generating plants. Copper Mines at Kilembe and the Cobalt mine in Kasese operate 5 and 10 MW [178] respectively of small hydropower plant.

2.5 Electricity Generation and Consumption

The sector has suffered from economic mismanagement. By 1986, Nalubale Power Station (Owen Falls Power Station) was capable of generating only 60 MW out of the 150 MW installed capacity, because of damaged machines, some of which had become obsolete. The machines were up rated to 180 MW in 1996. The UEB could generate approximately 170 MW at peak, which is equivalent to a 94% utilisation factor, against a projected demand of 230 MW. The deficiency was about 60 MW and the power demand was estimated to grow by 2 MW per month. [179]. This means that national energy demand is higher than supply. The electric energy consumption for different sectors is as shown in Figure 2.5.

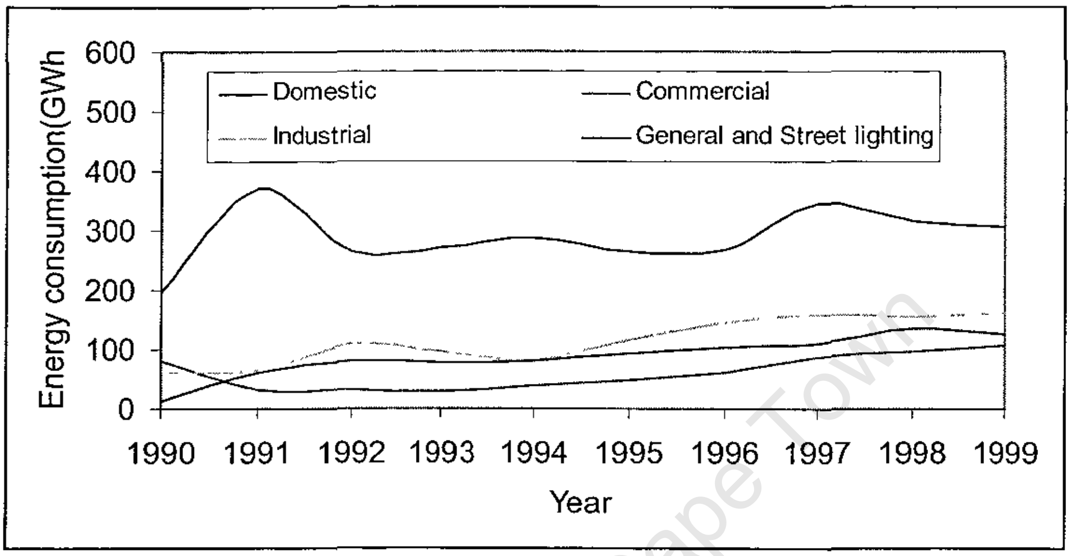

Figure 2.5: Electric energy consumption by sector [180]

Although there was fluctuation in electricity consumption over the last decade, demand has been increasing. The government has taken appropriate action to address electric energy demand by increasing the installed capacity of dams and introducing reforms in the electric energy supply sector.

The Kiira Power Station (Owen Falls Dam Extension), a 200 MW hydropower station, was constructed on the River Nile. The power generators have been installed in phases. The first phase was the generation of 80 MW, with capacity to be added in lots of 40 MW each. The Nalubaale Power Station supplies 180 MW.

In order to run the two power stations (Kiira Power Station and Nalubaale Power Station) it is necessary to have high quality information on the hydrology of the River Nile. A number of studies have been undertaken presenting data on average annual water flow out of Lake Victoria ranging from 650 to 1170 m^3 per second, with an average of 870 m^3

per second. Hydrology will certainly have a severe impact on the economy of the Kiira Power Station and the installation of the 4th and 5th turbines.[181]

The electricity demand was growing faster than supply, as the results household and commercial sector resorted to other alternative means of electricity supply to meet their needs. It was estimated that over 300,000 non-grid connected Ugandan households, nearly 10 % of all households, own and operate lead-acid batteries to power their TV's and lights.[182]

Hundreds of Ugandans have purchased their own generating sets and have installed over 60 MW to generate over 100 GWh per year. This clearly shows rural people's great desire to enjoy the amenities and benefits of electricity that urban people so easily take for granted[183]. It is estimated that at least 70 MW of diesel and petrol generators were imported into the country between 1993 and 1997. This implies that there was unsatisfied national electricity need to meet the growing demand.[184]

The government allowed an independent power producer to use thermal power plant to generate electricity for the next three to four years, starting in May 2005, in order to reduce frequency of load shedding. As a long-term strategy to overcome power shortage problems, Bujagali Hydro project is on a fast track. The Industrial Promotion Services has won the contact to develop the Bujagali Hydropower plant. The hydropower plant may be commissioned in 2009. Karuma Hydro project is also being fast tracked in order to cater for the existing demand in the country.[185]

2.6 Power Demand Projection

The Electricite De France (EDF) report of June 1999 covering the Optimisation Study for Hydrology on the Nile concludes that the remaining two turbines are likely to be under utilised unless there is departure from the agreed tapping of Lake Victoria. These generating units will be used for peaking power for short duration only and will represent a substantial backup for power generation.[186] The Government has officially accepted the EDF study.

A number of studies done by various consultants in the recent past agreed that the current demand for power far exceeds the available generating capacity. These studies include the National Electrification Planning Study (NEPS) prepared by EDF in 1991, the Extension of Owen Falls Power Station Study by Acres of Canada in 1990, the Hydro-Power Master Plan by Kennedy and Donkin in 1996, as well as the most recently released Optimisation Study - Load Forecasts by EDF, September 1998. The EDF study estimated that the current rate of growth of electricity demand surpasses that of the overall economy by about five percentage points every year. The results of different studies are as shown in Table 2.14.

Table 2.14 : Load forecast studies 1995-2020 (GWh) [187,188,189,190]

Study	1995	1997	2000	2005	2010	2015	2020
Electricite de France International							
Low		1520	1875	2518	3421	4065	5069
Base		1520	2379	3191	4414	5467	7049
High		1520	3209	5046	7699	9252	11651
Kennedy and Donkin Power Limited							
Low	1194	-	1365	1571	1849	2248	2756
Base	1194	-	1954	2339	2903	3773	5069
High	1194	-	2309	2972	3873	5963	8373
UNDP/ World Bank ESMAP							
Base	1220	1320	1490				

2.7 Power Transmission

The present power transmission includes 1,115 km of 132 kV high voltage lines, 54 km of 66 kV lines and 3,285km of 33 kV lines, while the network for distribution of power consists of about 3,443 km of 11 kV distribution lines and 6,496 km of low voltage lines. This network provides power to only 33 of the 54 districts.[191]

In 1998, Uganda had a contract to export to neighbouring countries: Kenya (30MW), Tanzania (9MW) and Rwanda (5MW) but it was suspended during the peak hours [192]. In 2000, the distribution network supplies power to about 200,000 customers. Households (55%), followed by commercial (24%), industrial (20%) and street lighting (1%) dominated the electricity consumption matrix in 2000. [193]

The present and future network for power transmission is as shown Figure A2.1. A 220 contained in Appendix A. Uganda was expecting to export electricity to the neighbouring countries including Kenya, Tanzania and Rwanda. Uganda has a comparative advantage over her neighbours. In Kenya demand for electricity is higher than supply, the country at times suffers from drought that also limits its hydropower supply. Secondly, there is anticipated development in the mining sector in Tanzania in the areas that are near the Ugandan border. These areas could have energy export potential. Bearing this and other economic development in the Great Lakes region in mind, development in electric power generation could have a significant impact on Uganda's exports. A 220 kV transmission line need be erected between the large hydro power plants in Karuma and Kamundini, Bujagali and main power consuming centre in Kampala.

The Development of large hydropower in Uganda is very problematic. The main concern is not only funds for construction (550m US$ International Finance Corporation for Bujagali) but also the political insurance guarantee that is required. For the Bujagali Dam this is US$ 250m of the total of about 85% multi-lateral investment. The guarantee agency (MICA) has to give cover for political risk and insurance, because other agencies were not prepared to cover the political uncertainty. While 15% is being obtained from other sources, including export credit agencies, Finland, Norway and Sweden.[194]

The World Bank inspection panel reported that the confidential Power Purchase Agreement, (PPA) revealed that the dam would have to double electricity prices within seven years if the shilling depreciates at 10% per year against the US$. The report further claims that development of other alternative power sources such as geothermal and that the environmental impact assessment was not given serious consideration. Among the environmental effects is that the dam will change the ecology of the river, the riverbanks, habitat and tourism. The World Bank Executive Board had approved the project, but decided to delay release of the money.[195]

It has been reported that the installation costs of Bujagali hydropower plant would be US$ 2.9 per kW, while the global average is US$ 1.8 per kW. The consumers will have to pay 14 cents per kWh, unless Uganda secures further debt relief to make the electricity affordable. [196]

A World Bank survey of business in Uganda revealed that the lack of reliable power is a major deterrent to investment. Every year, 90 hours of production are lost due to power outages and load shedding, at an estimated cost of 2% of economic growth. Power demand is growing at 7- 8 % per annum.[197]This situation needs to be addressed practically

Grid Extension

There have been extensions to the grid in some rural areas. The government plans to extend power to all district headquarters. The estimated cost of grid extensions and transformers is as shown in Appendix B Table B2.3. Extension of the grid to the rural areas is difficult and expensive due to the combination of poverty and dispersed settlements, lack of employment opportunities and heavy dependence on subsistence agriculture. Cost will also escalate if the terrain is hilly and rocky.

Small Hydropower Plants

Uganda has numerous potential small hydro plants located mostly in the western, south-western and north western parts of the country. The total potential is over 70 MW. Most of these sites are not developed. Three sites have been developed with assistance from donors, and they are Kisiizi Hospital 60 kW, Kuluva Hospital 160 kW and Kagando Hospital 120 kW.[198] The development of small hydropower plants requires less consideration to be given to environmental, socio-economic and resettlement issues than is the case for large hydropower plants.

The Uganda Electricity Regulator has awarded permits to three companies authorising them to supply electricity to the public within their vicinity; Uganda Rural Electrification Company to supply power to West Nile, Rukungiri and Kanungu; Mt. Elgon Hydro Power Company to supply power in Mbale; Hydromax Limited to supply power to Buseruka, Masindi and Hoima. Uganda Rural Electrification Company will provide generators for Arua and Nebbi. The generators will supply 18 hours of electricity. The programme is being funded by a loan from WB to subsidise the capital investment cost in the energy sector. A permit was also issued to the Kisiizi hospital to increase its capacity and to supply power to the nearby areas. [199]

The Performance of Uganda Electricity Board (UEB)

There has been improved performance in some areas by the UEB in the last eight years. Revenue collection has improved and the generation capacity per employee has more than doubled over the last decade. [200] The general performance of UEB is as shown in Table 2.15.

Table 2.15: Performance indicators for UEB

	1992	1994	1996	1998	1999	2000
Generation per employee (GWh)	0.33	0.32	0.34	0.61	0.66	0.84
Sales per employee (MWh)	259	234	252	426	433	561
Customer per employee	37	34	37	79	81	71
Billed as % of Generated	68	64	69	66	60	66
Collected as % as Billed	50	55	83	96	86	83
Collected as % of Generated	34	35	57	63	52	54
Yearly sales per customer (kWh)	6933	6875	6728	5432	5335	4058

Table 2.15 does not however give the financial state of the UEB. There has been growth in the supply of power over the last decade, but system losses are still high as shown below in Table 2.16.

Table 2.16 : Energy Supplied by UEB 1990-1998 (GWh) [201]

	1992	1994	1996	1998	1999	2000
Owen Falls Power Station Hydro Generation	999.3	1016.8	1129.0	1232.4	1340.5	1537.9
Thermal (Diesel) Generation	1.0	1.4	1.1	1.2	1.2	1.2
Purchases from Mobuku	4.4	9.0	9.6	7.2	11.6	15.4
Imports from Rwanda	-	-	0.3	0.3	0.9	1.1
Total Units Supply	998.7	1027.2	1139.7	1240.8	1353.3	1554.5
System losses (% of generated)	31.7	36.2	30.8	34.2	39.7	34.4
System losses	224.5	276.7	300.8	367.1	463.2	442.2
National Consumption	484.8	487.5	676.7	705.9	702.2	843.0
Domestic	263.3	285.5	366.4	316.6	307.1	311.8
Commercial	32.7	38.6	62.2	98.3	107.3	121.9
Industrial	109.5	81.8	143.9	154.3	162.7	206.2
General	72.6	71.0	102.1	135.5	122.7	201.2
Street lighting	6.7	6.4	2.1	1.2	1.2	1.9
Export						
Kenya	283.4	237.1	1128.6	136.3	152.8	229.5
Tanzania	-	15.1	131.2	21.3	21.1	21.5
Rwanda	-	-	0.9	1.3	0.04	0.1
Load Factor %	75.2	72.0	74.1	54.2	58.9	67.6

The official records show that there were over 148,000 grid electric users in 1999. The average per capita consumption is only 44 kWh per year for all users, compared to 170 kWh for Kampala-Entebbe districts and less than 10 kWh in most outlying districts. An estimated load of up to 80 MW is shed every day at peak hour. [202]

In general car batteries are used more in the central region as shown in Table 2.17. The average potential kWh per month of a car battery is estimated at 3.5 kWh. Car batteries are expensive.

Table 2.17: The percentage of households using car batteries [203]

Income Category	Region			
	Central	Eastern	Western	Northern
Households	18 %	7%	5%	4%

Gas Turbines

West Nile Region is not connected to the main grid. Arua is the fastest growing town in West Nile Region. Installation of gas turbines in Arua is one of the options put forward by the World Bank to alleviate the electricity shortages for Arua town with an estimated population of 80,000. At present, the UEB system serves less than 1000 customers including the commercial, residential and officials for about 4 hours in a day. The advantage of gas turbines is that they can be operated with a number of fuels, such as diesel, kerosene and LPG. This is a short-term solution to power supply. In the medium term, after installation of a mini hydro plant, the gas turbines will be used for peaking / back up.[204]

2.8 The Electricity Tariff

The electricity tariffs vary from one country to another depending on the type of fuel used for electric generation. The comparison of tariffs of four different countries is given in Table 2.18 below:

Table 2.18: Comparison of tariffs (US cents per kWh) (1993)

Category	Zambia	Lesotho	Botswana	Ethiopia
Domestic	1.23	8.5	10.4	6 – 8
Commercial	3.48	8.0	9.5	16.6 – 20
Industry	1.75-4.17	6.9	4.75	11 – 22

Some countries have uniform tariff while others set their tariff depending the source of electricity. In all cases the grid connected hydro based system tariff is lower than diesel generator based system. In the case where a country is implementing uniform tariff, the grid cross-subsidising the off-grid diesel generator based supplies. [205]

In most cases, the tariffs for industrial sector is lower than household with exception of Ethiopia. In the four countries (Table 2.18), supply of electricity to the population remains to be the main problem. [206]

The most important factor that limit provision of electricity to the population are the high cost associated with distribution systems and unfavourable policy by where a full cost of connection is born by the customers. There are some countries such as India, in which poor household get free connection through a single point. This is because in India electricity supply is considered as the basic need for the population. [207]

In general terms, there is general power shortage in both South African countries and in the Great Lakes region of Africa. There are few countries with excess capacity. To address the issues related to the shortfall, there is growing regional cooperation to solve the problem experienced by a number of Southern African countries. [208]

Some countries used to subsidise electricity, such policies are both economically and environmentally unproductive. It leads to excessive demand and at the same time reducing the revenue base for suppliers. It is contented that if the developing countries could pay the true marginal cost of supply, the electricity demand would have reduced by 20% .[209] Lets consider the example of the Uganda Electricity Board.In order increase access to electricity, the Uganda Electricity Board operated a heavily subsidised domestic tariff. The electricity subsidies were implemented by: [210]

- setting a lifeline tariff for the poor,
- setting part of the tariff below the long-run marginal cost for household and industrial consumers;
- setting a 79 per cent subsidy on electricity connection to domestic premises.

The electricity tariff was revised first in June 2001 and again in September 2002. The trend was to increase the tariff so that consumers could pay the marginal cost of the energy they consume. Further in 2005, the Electricity Regulatory Authority (ERA) announced a 24% increase in power tariffs. The Electricity Regulatory Authority has approved electricity tariff which will be applicable from 1st April to 31 December 2005.[211] The new tariff is shown in Table 2.19.

Table 2.19: Electricity Tariffs: (UGShs per kWh)

Energy Tariff	Domestic	Commercial	Medium Industries	Large Industries	Street/Light
Average	212.5	204.4	178.9	71.9	201.5
Peak		259.9	232.1	116.3	
Shoulder		200.5	175.0	82.5	
Off-peak		100.8	80.2	34.2	

The new rates have affected household and commercial sector most. The large and medium scale industries can benefit most from off peak tariff. The industrial retail tariff unit charge varies between UGShs 116.3 and 34.2 per kWh. This excludes the payment of a maximum demand charge which varies between UGShs 3,300 to 5,000 per kVA.

The manufacturering sector in Uganda felt that the increase in electricity tariffs will hurt them because they are already disadvantaged in the region due to taxation. They only had a comparative advantage in the production of goods because Uganda had the lowest tariff in the region.[212] Yet the fuel price is high making thermal power, which is being looked at as an immediate option, very expensive.[213]

According to the ERA, the increase was implemented after thorough analysis and was required. It further stated that the rates would help ERA to improve the electric supply by contracting a private firm to design, construct, own operate and maintain a diesel thermal plant.[214]

2.9 Petroleum Resources

Although petroleum production has not been established in Uganda, the hydrocarbon generating capacity of its rift basins is very evident. The potentially productive area is the Alberine Graben stretching from the border with Sudan in the north to Lake Edward in the south and it extends to a portion of Democratic Republic of Congo. Geological and physical work to date had indicated that source rocks and maturity are guaranteed in Albertine Graben. [215] Hydrocarbons have been generated as proven in the nine known areas of substantial oil seeps within the Graben. There are five exploration areas in the Albertine Graben. Exploration Area 3 was licensed to the Heritage Oil and Gas Company, and Exploration Area 2 was licensed to Hardman Petroleum (U) Pty Limited of Australia while the remaining acreage is available for licensing. [216] The areas which are licensed are as illustrated in Appendix A Figure A2.2.

The seismic survey of the Semliki area for the Petroleum Exploration Sector revealed very good prospects for petroleum generation and accumulation. The data acquired from the geological and geophysical survey in the Pakwach-Rhino Camp basin confirmed a well-defined deep sedimentary basin. [217]

As for petroleum, the main source of petroleum imports to Uganda is the Middle East. There are refineries at Mombassa in Kenya and Dar es Salaam in Tanzania. Most the petroleum is transported by road. Uganda imports about 15 per cent of its petroleum needs through Tanzania by rail via the port of Mwanza on Lake Victoria. [218]

A feasibility study has been commissioned to establish the viability of laying a 320-kilometre pipeline between Kitale and Kampala. The estimated cost would be US$ 80 million. It is likely that a private firm would invest in the project. The capacity of the pipeline would be 220,000 litres per hour. The possibility of building 1,450 km pipeline through Tanzania to Uganda is also being examined. [219]. All these attempt at alleviating the energy problems in Uganda.

2.10 Petroleum Products.

Petroleum is the main source of energy for transport. It is also widely used for lighting in households, while in industries it is used for steam generation. All petroleum products are imported. This imposes constraints on foreign exchange. The consumption of petroleum will increase as the country continues to develop, as trends indicates in Figure 2.6 below.

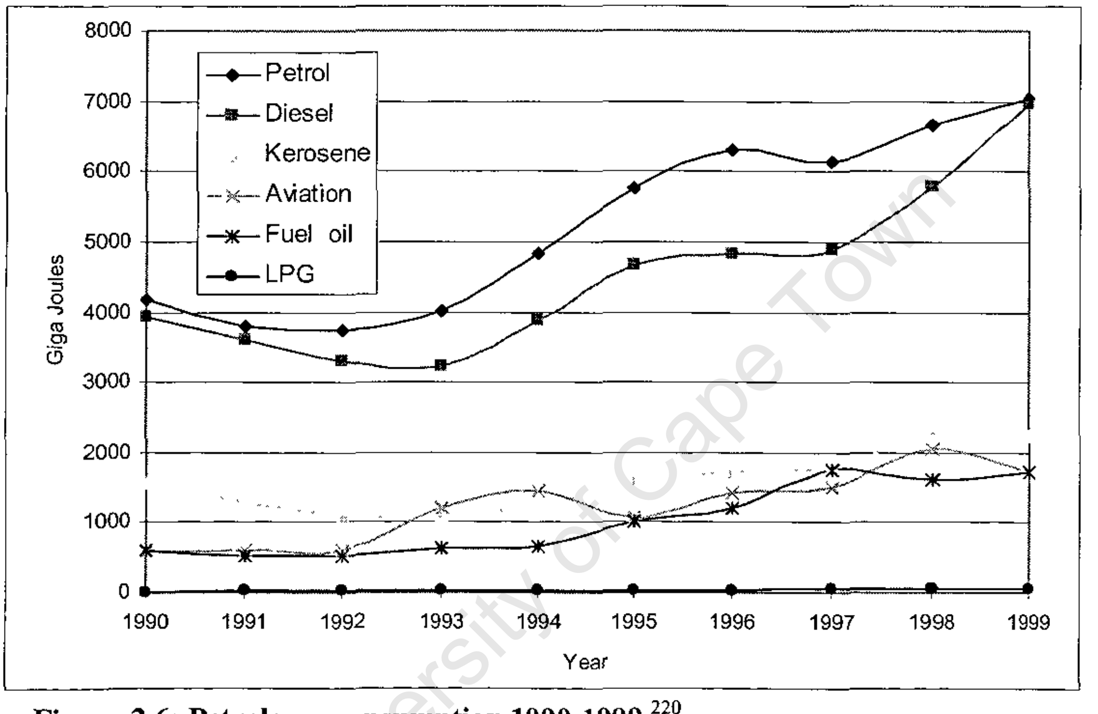

Figure 2.6: Petroleum consumption 1990-1999 [220]

As figure 2.6 demonstrates, there is a general growth in demand for petroleum products in Uganda as shown in Figure 2.6 above. Petroleum consumption is high due to increasing importation of mostly second hand vehicles. This compounded by the fact that due to the high price of petrol, there is a fuel shift towards diesel vehicles. On the contrary, consumption of LPG is still very low.

Figure 2.7 below shows the fluctuation in petroleum consumption. The consumption is increasing because of importation of vehicles. There is smuggling of fuel from the neighbouring countries due to the high prices of petroleum products in Uganda. Therefore the official figures do not give the net petroleum consumption in Uganda. It is estimated that at least 10 percent of the petrol, diesel and kerosene consumed in Uganda is smuggled. This may not be surprising because the pump price of petroleum products in Uganda is the highest in the region.

Currently, as pointed earlier, Uganda imports its entire petroleum requirements from the Middle East countries. There are nineteen petroleum companies in Uganda, the largest being Shell, followed by Caltex, Total and Gapco .

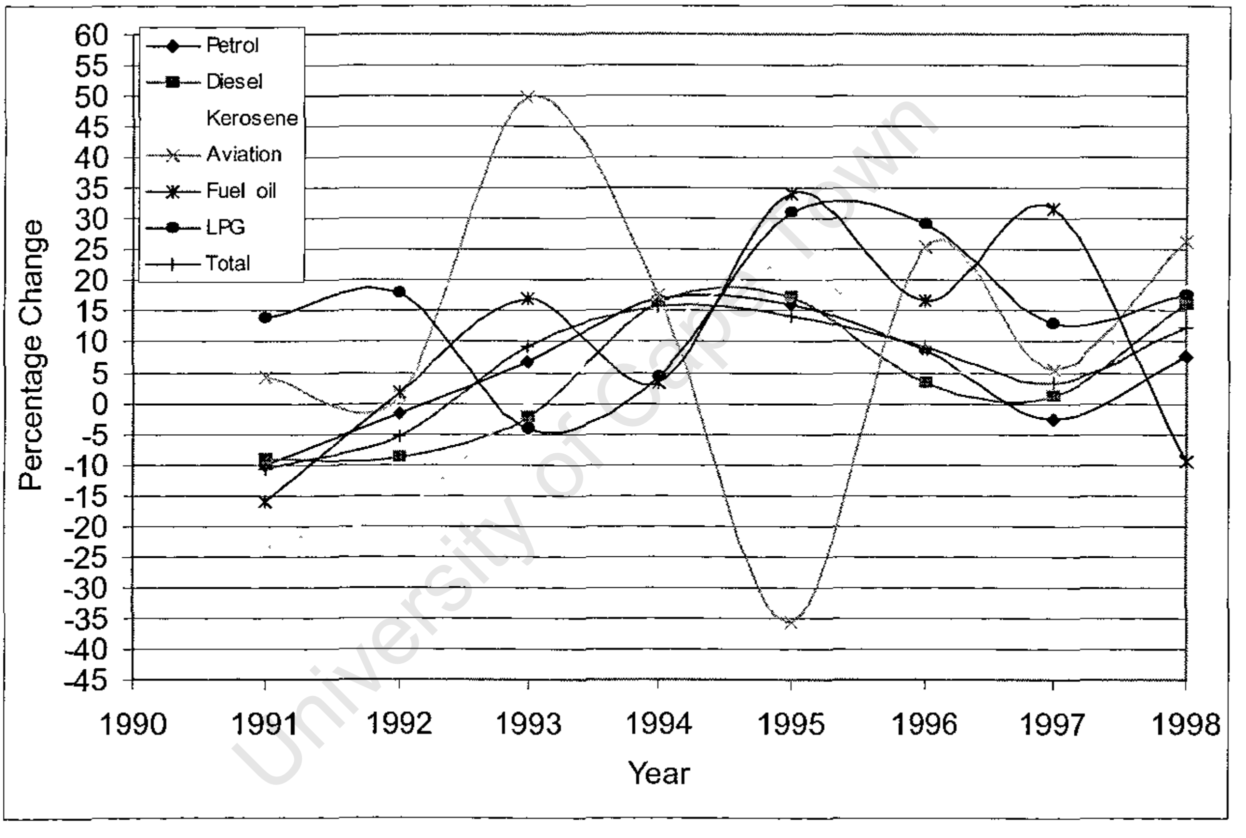

Figure 2.7: Percentage change in consumption of petroleum products

The use of LPG has not been fully exploited in Uganda. Most families use kerosene for their lighting needs and a negligible amount for cooking. Aviation fuel exhibits the highest demand fluctuation. This implies that there are alternative supply options for aviation such as refuelling in Kenya where fuel is cheaper.

With the low per capita petroleum consumption of 807.5 MJ in 1994, [221] and 873.2 MJ in 1999,[222] it is not unreasonable to assume that this will increase significantly as the economy improves.

In 1999, for example, petroleum imports represented 9% of the total imports. This is equivalent to 25% of the total national export earnings from commodities. Over the last decade, 20% to 25 % of the government tax revenue has come from petroleum products. [223] In 2002 the petroleum import bill was US$ 160 million, representing 8 % of the total imports. This is equivalent to 25% of the total national export earnings from commodities. [224]

Table 2.20: Regional comparison of fuel prices for premium motor sprit in 1999 (UGShs) [225]

Country	Pump Prices	Tax & Duties	Company Margins
Kenya	773	324	119
Tanzania	895	429	80
Uganda	1330	539	233
Rwanda	1196	638	55

Uganda has the highest pump price for premium motor spirit in the region as illustrated in Table 2.20. Although Rwanda has the highest taxes and duties, the pump prices are still less than those in Uganda. In 1999, Ugandan oil companies were getting 17.5 % as the company profit margin based on the pump price, which is high when compared with only 8.9 % in Tanzania and 4.6 % in Rwanda. However in 2002, the Ugandan companies had relatively high profit margins in the region of Ushs.180 compared to Ushs.110 in Kenya and Ushs.80 in Rwanda and Tanzania. [226] The Ugandan companies claim that the capital investment in Uganda is very high due to the environmental and other standards that have to be met when putting up filling station.

Kerosene Consumption in Households

In a survey carried out after interviewing 2,000 households in 14 districts, the kerosene consumption in the four regions of Uganda was established. Of the total sample, 948 households were from the peri urban areas and 1,052 households were from the rural areas.[227] About 16% of all households used only candles for lighting, while 85% of the households used kerosene for lighting and supplemented kerosene with a small amount of candles. About 90 % of all the households used kerosene as the main lighting fuel and used a significant amount of dry cells and car batteries for small appliances and television sets.[228]

Table 2.21: Household monthly consumption of kerosene for lighting by income and region[229]

Region	Income category	Consumption Litre/month	Number of households	Hours of lighting per day
Central	Low	3.7	294,240	2.6
	Medium	5.4	298,620	3.9
	High	6.4	189,120	4.8
	Total cases	5.1		3.7
Eastern	Low	3.5	283,199	2.6
	Medium	6.0	318,311	4.4
	High	7.4	148,239	5.4
	Average	5.6		4.1
Western	Low	2.7	402,085	2.0
	Medium	4.6	354,143	3.2
	High	7.9	113,542	5.7
	Average	5.0		3.6
Northern	Low	3.6	77,214	2.6
	Medium	4.6	74,567	3.3
	High	7.6	46,236	5.5
	Average	5.3		3.8

Table 2.21 above, shows that families with higher income consume more kerosene and they use lighting for longer period than low-income families. The *tadoba* (wick lamp) is mostly used in rural areas, and consumes and about 0.046 litres/hour.[230] In most of the peri urban and urban areas hurricane lamps are used. The earlier studies by Voravate Tig Tuntivate,[231] did not measure the fuel consumption of other appliances such as hurricane lamps and kerosene stoves.

2.11 Renewable Energy

Solar, biogas and wind energy sources have a role to play and their use should be promoted, but they will play a minor role in Uganda's energy provision in the foreseeable future. Renewable energy development has received attention in Uganda, and many pilot activities have taken place. However, only a fraction of these resources are utilised due to a number of problems such as the lack of co-ordination and little exchange of information and experience, limited follow-up and very limited monitoring and evaluation. The government has developed interests in assessment of alternative energy resources.

Solar

Uganda lies astride the Equator, where solar radiation is generally expected to be high. Unfortunately, solar radiation data exist for very few locations such as the University Farm in Kabanyolo and Entebbe International Airport. These areas experience average annual solar insulation of 650W/m^2 and 588 W/m^2, respectively. The amount is reportedly low due to cloud cover during the recording period. [232]

Solar radiation is fairly uniform all over the country with estimated values of 5 - 6 kWh/m^2/day. The range of sunshine hours is between 5-7 hours per day. The private sector has shown interest in photovoltaic applications, because of the on-going energy for rural area transformation project. The estimated minimum insolation (by Solarex Corporation) is 5 and 4 kWh/m^2/day [233] for northern and southern parts of Uganda respectively. This data was based on a global study of solar irradiation. Whereas the

Meteorological Department maintains the sunshine hours and cloud cover data for the country, no detailed study has yet been undertaken to measure the insolation in Uganda.

Of recent, the Ministry of Energy and Mineral Development has identified solar energy as one of the most important energy resources. Electrowatt Ekono Oy of Norway was assigned to carry out the assessment of national solar resources.[234]

It is estimated that there are about 20,000 installed PV units in Uganda, used mainly for lighting. [235] The largest solar pump in Uganda is installed in Kisoro, and has an output of 36 kW. It has 492 modules of 75 W each. It is used to supply drinking water. It was part of the South Western Towns Water and Sanitation Project. The pumping capacity is 150 m^3 per day. More than 50 kW has been installed since the project began in 1996.[236] The water is transported by gravity-feed and by a photovoltaic pumping system. The system was installed as part of bilateral development between Austria and Uganda. In this particular energy project, the local population has been included in the planning and decision-making phases of the project from the very beginning. The output parameters for solar pumping systems in the selected areas as well as related technical data and cost are illustrated in Tables 2.22 and 2.23.

Table 2.22: Output parameters for the solar pumping system [237]

Solar pump system	Population of supply area	High-level tank (m^3)	Output per day (m^3 day)	Total pumping head (m)
Kisoro	10,000	400	150	132
Kihihi	6,000	160	80	48
Ryakarimira	1,500	65	17	150
Bugangari	1,000	40	20	80
Ishasha	800	45	15	35

Table 2.23: Technical data and costs for solar pumping system [238]

Solar pump system	Output (kW)	Pumps	Specific installation cost (Euro /kW)
Kisoro	3 x 12	5.5 kW, 3 x 230V	5,100
Kihihi	6.75	4.0 kW, 3 x 230V	6,000
Ryakarimira	5.4	4.0 kW, 3 x 230V	7,400
Bugangari	4	2.2 kW 3 x 230V	6,300
Ishasha	1.2	3 x 65 V AC	8,500

Currently, there are several current projects in the Ministry of Energy and Mineral Development to address the issues of rural electrification. Among the projects is the Uganda Photovoltaic Project for Rural Electrification (UPPPRE).[239] This project aims, among other things, at putting in place a sustainable financing mechanism for solar photovoltaic, whereby customers will pay a manageable up-front lump sum followed by instalment payments.

The other one is the Africa Rural and Renewable Energy Initiative (AFRREI), [240] whose main aim is to increase the rural electricity coverage from the present low value of 1% to 10% in the next ten years, through development of decentralised power schemes, grid extension and the development of some 50 MW of renewable energy resources.

Biogas

Three biogas projects have been funded since 1981. Over 70 digesters have been installed since that time. Biogas has been viewed as a means to reduce biomass energy demand and thereby conserve Uganda's forestry resource base. The cost of a household digester (US$ 700 to US$1,300) is far beyond the means of all but the wealthiest households. [242] According to a report by ESMAP in 1996, it was suggested that the study of biogas should be discontinued because of its failures. However, the Agricultural Engineering and Appropriate Technology Research Institute of the National Agricultural Research

Organisation have played a leading role in the research and dissemination of biogas technology.

Wind

The first systematic investigation of wind resources was carried out in 1996. The study involved investigations on territorial wind distribution.[242] Preliminary analysis of the wind resources in Uganda was carried out based on eleven sites. The Meteorological Department, Ministry of Water, Lands and Environment supplied the data. The instrumentation was not uniform at all eleven sites. The data for four years was analysed (1989-1992).[243] The results obtained from the eleven sites are shown in Appendix B Table B2.4. The preliminary results show that wind is not very promising for intensive power production. For example, the wind speed distribution is shown in Appendix A Figure A2.2. Generally, the wind speeds are below three meters per second. However, it can be used for pumping water for irrigation and drinking water mostly in the arid regions.

The use of wind energy has been restricted in Uganda to remote dry regions of Karamoja where 12 wind water pumps are installed. Local innovative entrepreneurs installed wind generators for generating electricity with capacity of 20 kW, on the Sese Islands and at Entebbe. [244]

There are cases where the windmills for water pumping have been installed in an unsuitable location due to mistakes made by the installers. At times the buyers of these technologies are not well informed of the basic parameters that can affect the performance of the equipment.

As part of the remedy, Electrowatt Ekono Oy of Norway has been awarded a contact to map the potential of wind energy resources in Kotido, Moroto, Kabale, Kisoro and Ntungamo districts. This contract is part of the Ministry of Energy and Mineral Development efforts to assess the renewable energy potential of Uganda. [245]

Ethanol

In 1992 the Government considered producing ethanol in Uganda. The economic analysis included in the study indicated that the project was not viable for several reasons, namely, the plants were going to be owned by the sugar estates and hence partly owned by the Government, which might have caused some financial difficulties and conflicts of interest. Furthermore, the landed price of petrol is lower than the cost of ethanol production .[246]

Ethanol has been blended with petrol up to 20% in Kenya, Malawi and Zimbabwe, but no successful total replacement for petrol has been achieved in the region.[247] The use of ethanol results in emission 30-50 % of those from gasoline when considering the fuel cycle. The use of the ethanol to blend with petrol can result in a reduction of the greenhouse gases. Ethanol is a renewable energy form that contributes directly to climate change mitigation; the production and use of 1 litre of ethanol to replace gasoline avoids emission of 0.54-0.57 kg of CO_2.[248] There are other environmental effects that are associated with use of ethanol as a fuel that should be taken under consideration.

Geothermal

The potential for geothermal power is evident from hot springs found in the Western Region around the shores of Lake Albert. A study by UNDP in 1970 [249] and Technology Consultants Ltd in 1993 [250] put the national potential at 450 MW.

A study was carried out to prioritise and to select project sites for geothermal development. Drilling for geothermal energy was done at Buranga and Kabiro along the Albertine Rift Valley. The two areas indicated a reservoir with a temperature of 167 ^{0}C to 190 ^{0}C at Buranga and 250^{o}C to 257 ^{0}C at Kabiro. Temperatures in excess of 108 ^{0}C are sufficient for geothermal power generation, if binary technology is used. [251] In this direction, the Ministry of Energy and Mineral Development has given a contract to Electrowatt Ekono Oy of Norway, to assess the geothermal energy in the districts of Katwe, Kibiro and Buranga. [252]

Peat as Source of Energy

There are peat deposits in Uganda. The amount has not been quantified. Unfortunately there are a number of factors that will restrain its early exploitation. The main drawback is the low calorific value of peat, which gives it a high transport and distribution cost and makes it uncompetitive. The potential areas for peat in Uganda are Apach, Lira, Soroti, Tororo, Kumi, Mbale, Kamuli and Luwero .[253]

2.12 Energy and Environment

As the result of human activities, there are certain type of gases when emitted excessively, can have profound effect on environment. Their emission is said to have linked to global climate change and enhanced greenhouse effect. Consequently, there were changes in climate and ecosystems. Naturally, it is the normal greenhouse effect of the planet's atmosphere that traps heat from sun thereby enable life to be sustained, but the greenhouse gases emitted by human activities upsets the balance. [254]

Most of the economy of African countries is highly dependent on agriculture and natural resources, as the result there is a strong link between environment and economic development. The deteriorating environment can easily be reflected by the current levels of land degradation, deforestation, atmospheric pollution, over-harvesting of natural resources and poor urban conditions. This calls for action to be taken so that the African prospect of sustainable development will not be undermined. [255]

In most of the households, the use of fossil fuels and traditional use of biomass energy sources are the major contributors to serious environmental and health problems, [256] such as: particulate matter and other pollution from energy threaten human health at household level and local level in two major ways.

- In cases where the emissions are emanating from energy sources, these include suspended fine particles and precursors of acid deposition, which in turn contribute to air pollution and ecosystem degradation.
- Emissions due to human activities greenhouses mostly from the production and use of fossil fuels are altering weather patterns.

Since energy sources and systems are the main causes of emissions, it is imperative that the choice of energy source should be by the level at which it will support sustainable development[257] including:

- Improved accessibility to all and particularly the poor
- Comparatively end use devices should be of higher efficiency
- Whenever possible use of local renewable energy should be utilised.

2.12.1 Emissions in the Energy Sector

Uganda is experiencing pressure for development including technical advancement and increased use of fossil fuels which contributes to the emissions of greenhouse gases. Using the bottom-up methodology in estimating the CO_2 emissions from petroleum products, in 1994 an estimated 708.61 thousand tonnes of carbon dioxide was emitted from the transport sector and cement industries alone.[258]

There are on-going projects that take into consideration the emissions in the energy sector. The emission can be tradable if the quantities are high. Uganda has benefited from the World Banks Prototype Funds to supplement capital investment in Nyagak Hydro power Scheme. [259] The hydropower will replace the use of diesel generators and the use of kerosene in households. The same application can be considered for photovoltaic.

In addition, Uganda is a signatory to the United Nations Climate Change Convention. As a result much effort is underway to develop projects which are able to benefit from the Global Environmental Facility and the Clean Development Mechanism. [260] The government would be well-advised to increase its manpower capacities in this area.

2.12.2 Indoor Air Pollution

The effect of air pollution is a health hazard which is affecting population worldwide. Indoor air pollution which is very common in the developing countries is a greater concern to health than outdoor air pollution. At some locations, the pollutants concentrations can be as high as exceeding World Health Organisation guidelines by a factor of more than 100. [261] Annually, it is estimated that 1.6 million people in the poor countries die from smoke from cooking in poorly ventilated kitchen; most of them are women and children .[262]

Biomass fuel is used in different forms, such as wood fuel, charcoal; agricultural waste and coal are main cause of indoor air pollution. The smoke emanating from combustion of these biomass fuels is a complex mixture of aerosols which contain significant amounts of carbon monoxide, suspended particulate matter, hydrocarbons and nitrogen oxides. This smoke when inhaled, could lead to the risk of chronic respiratory disorders, including chronic obstructive pulmonary disease. There are several organic compounds that are toxic, mutagenic and carcinogenic which are the main components of smoke. [263]

There are several initiatives worldwide trying to address the issues related to indoor air pollution. As an example, World Summit on Sustainable Development in Johannesburg, The Partnership for Clean Indoor Air (PCIA) was launched. Among its the objectives was to address the increased environmental health risk faced by more than 2 billion people in the developing world who use biomass indoors for cooking and heating. [264]

The Centre for Entrepreneurship in International Health and Development of the University of California at Berkeley, United States, [265] will promote local technology and the Rocket Stove (It is an improved Lorena wood mud stoves with two pots and a chimney) in urban areas of Uganda. This is inline with the goals of the PCIA pilot project, which include:

- to initiate wood stove production in a low-income urban neighbourhood
- to market stoves, initially in the pilot phase, it is anticipated that at least 1,000 rocket stoves will be sold within 15 months.
- to study the effect of using a chimney-less improved Lorena stove on indoor air pollution. Measurements of critical parameters will be made. The study will be carried in Makindye, Kampala City. It is anticipated that there will be 40% reduction of harmful emission. [266]

In a study carried out in India by Kirk Smith, it shows that the concentration of suspended particles (compare with data in Table 2.24), when using biogas, is comparable to LPG. It implies that the use of biogas in household can reduce indoor air pollution and consequent health problems resulting from indoor air pollution. [267]

Table 2.24 : Net total suspended particles' concentrations in flue gas [268]

Fuel	Total Suspended Particles (Mg Per M^3)
Biogas	0.25
LPG	0.32
Kerosene	0.48
Crop residue	5.74

Table 2.24 shows the suspended particle concentrations in flue gas for different types of fuels. It can be seen that with the use of crop residue fuel, the total suspended particles is more than 10 times higher than when using gas and liquid fuels. Particles up to 10 microns in diameter (PM10) have been commonly measured, but researchers have looked at all suspended particles. However, recent evidence suggests that the very smallest particles are most dangerous and consequently some studies have measured down to 2.5 microns in diameter (PM2.5). [269] During the use of fuel for cooking and heating in households, carbon dioxide is emitted into the atmosphere. Typical figures are shown in Table 2.25.

Table 2.25: Carbon Emission Factors (CEF) for various fuels [270]

Fuel	CEF (TCO_2/Kilocaries)	CEF (TCO_2/KJ)
Natural gas	173.7	727.2
LPG	195.3	817.7
Kerosene	222.5	931.6
Crude oil	249.8	1045.9
Peat	328.1	1373.7
Solid biomass	339.4	1421.0

The CO_2 from biomass usually does not result in a net increase in atmospheric concentration because the plants absorb it during photosynthesis. However, as shown in Table 2.25 above, ıf biomass is not harvested sustainably, it will not be carbon neutral. Using firewood contributes to various pollutants in the kitchen. Using 1 kg of wood/hour in 15 air change per hour for a 40 m^3 kitchen emits pollutants as shown in Table 2.26 below.

Table 2.26 : Pollutant from 1 kg of wood per hour, 15 air changes per hour 40 m^3 kitchens [271]

Pollutant	Emission (mg/m^3)	Allowable Standard (mg/m^3)
Carbon Monoxide	150	10
Particles	3.3	0.1
Benzene	0.8	0.002
1,3-Butadiene	0.15	0.0003
Formaldehyde	0.7	0.1

In developed countries like the United States, the department which is concerned with the environment, the Environmental Protection Agency, has set standards for pollution levels in various places. Overall, it is evident that use of wood produces pollutants which are often above allowable limits.

In contrast, a project which was carried out in Kenya to monitor intervention to alleviate indoor air pollution involving 50 rural households, showed that the mean 24-hour values for inhaled particulates of 5526 $\mu g/m^3$ in Kajiato and 1713 $\mu g/m^3$ in Western Kenya. These values are too high when compared with United States Environment Protection Agency standards where annual acceptable levels are $50\mu g/m^3$. It can be seen that daily rates are 100 times greater in Kajiato and over 30 times higher in Western Kenya than accepted values. [272]

There are various interventions if implemented can contribute towards reduction of exposure to indoor air pollution. Improved cooking devises like stoves and use of cleaner fuels such as biogas, can form a good combination in reducing the effect of indoor air pollution. Other interventions should be carried out at design stage. For instance kitchens with improved ventilation can reduce indoor air pollution in the living environment. There are other low cost interventions which are based on human behaviour such as proper operation of stoves and avoiding smoke can decrease the effect of indoor air pollution. [273]

Indoor air pollution and household energy impacts on a wide range of interrelated issues including health, especially that of women and children lives, the environment, and socio-economic development. It implies that to solve a problem of indoor air pollution will require a multi sectoral approach to be taken if implementation is to be effective and sustainable. In most cases projects are donor driven consequently there is little participation of major stakeholders. [274]

2.13 Energy Policy

Uganda has developed a comprehensive and explicit energy policy. [275] The Policy goal is to meet the energy needs of Uganda's population for social and economic development in an environmentally sustainable manner. Let us note that, the energy sector comprises of the following sub-sectors: power; petroleum; new and renewable energy Sources; and atomic energy. The energy policy objectives for Uganda have been formulated in the context of the following settings: [276]

- The existing economic, social and environmental policies.
- The nature and linkages of the energy sector with other sectors.
- International and regional linkages of the sector.

Power Sub-sector

The power sub-sector covers electricity generation, transmission and distribution including rural electrification. The first detailed policy, enacted in 1999, was the Electricity Act. [277] It covered the power sub-sector including electricity generation, transmission and distribution including rural electrification. It provides for the establishment of the Electricity Regulatory Authority (ERA). Among the functions of the

ERA, was to be responsible to provide for the licensing and control of activities in the electricity sector. Overall, the Ministry of Energy and Mineral Development is responsible for policy and the ERA regulates the industry independently of the Ministry.

The Petroleum Sub sector

The petroleum sub sector covers both upstream and downstream industries. Upstream deals with exploration, development and production, while downstream covers transportation, refining, distribution and marketing of petroleum products. The Petroleum Act of 1985 and the Petroleum Regulations of 1993 regulate upstream activities. The downstream industry is governed by the Petroleum Act of 1964 and several regulations made there under.[278] Both of these have influence on the energy demand and supply in the country.

Petroleum Exploration

Within the framework of the 1985 Petroleum Act, the Government of Uganda, through the Ministry of Energy and Mineral Development, is obliged and prepared to enter into agreements with responsible companies for mutually beneficial exploration, development and production of hydrocarbons in Uganda.

However, the existing legal framework for managing and regulating the down stream petroleum sub-sector is outdated and requires complete upgrading. A review of the legal framework has been undertaken and proposals for a new Petroleum Supply Law and Regulation have been prepared. [279]

Atomic Energy Sub-sector

Atomic energy use in Uganda is limited and is applied mainly in the agricultural and health sectors. Atomic Energy uses are regulated in order to protect the public and the environment from dangers arising out of improper practice and uses of ionising radiation. Atomic energy matters are regulated by the Atomic Energy Decree No.12 of 1972. [280]

2.14 Energy Models

Energy models are used in presenting the current energy situation for a given country and develop projections for future under different scenarios. Energy models have become standard tool in energy planning. Applications of energy models are becoming increasingly popular in developing countries for it allows investigation of functional relationship between various energy related variables. The results, if evaluated objectively can provide basis for future actions. The driving variables are used in conjunction with explained variables through equations in the model. In order to apply any model, there is a need for data bank of the past and present for they are useful in projection of future energy demand. [281]

Most of the energy models were developed as large econometric or optimisation based systems of models. The purpose was to study the impact of different policies of economic development, environment impact and natural resources. [282]

There are several types of energy models that are used in energy planning. In most cases, energy model can be classified as a supply/demand or both. There are distinction of energy models which are based on the chosen methodology, namely the three main categories are: [283]

1. Econometric models
2. Optimisation models
3. Simulation models

2.15 The Model Types

Econometric models

Econometric modelling may be defined as use of statistical techniques in dealing with problems of an economic nature. It is a branch of economics in which hypothesis are mathematically formulated and statically tested. An econometric model relies on mathematical and statistical methods to study economic and energy systems. There is a strong relationship between economic development and energy demand. The model can be used to formalise the relationship between, energy demand and relevant explanatory variables. Hence the econometric model can be considered as giving a representation of the changes in energy demand and energy uses in different sectors. The most common variables are related to energy sources, the energy sectors or the energy uses. [284]

Econometric models have the following advantages:

- They are simple models that can be applied in a short time for planning exercise.
- They are based on mathematical formulation, incorporating an objective approach
- The user can choose a model depending on the level of sophistication.

The models have the following weaknesses:

- In most cases, it is only in dynamic models, with some restrictions that allow inclusion of long term evolution and structural changes.
- The availability of reliable data base is an important element.
- The results of simplified models may contain some questionable values.

Optimisation Models

Optimisation is one of the methods of economic approaches to select from different alternatives the most favourable according to their basic objective function. Optimisation requires an accurate formulation of the system equations and the existence of reliable data bank. The data has to be accurate in respect to quality and reliability. Some developed countries have implemented optimisation models in the energy sector such as in the electricity supply and operation of energy equipment. [285]

There are two types of optimisation models commonly used in the energy sector:

- Optimisation which is based on energy supply and or/ demand, which is sector specific over a period of time.
- Optimisation which is based on the operation of a specific energy supply system.

Among the advantages of optimisation models, are they form and direction of energy distributions by:

- The implementation of shadow prices in order to control supply and demand
- The implementation of costs which are unrelated to an optimal solution and hence the distribution is more effective.

Simulation Models

Simulation is a process whereby any systems can be transposed and represented by a similar or less complex model. Simulation models try to move from rigid mathematical formulation without neglecting logical evaluation. Using simulation model it is possible to represent all possible and probable future events based on the present. That is often presented in form of scenarios. Although simulation models maintain logical evaluation, it is not based on the rigid mathematical analysis. [286]

The simulation models have the following advantages:

- Greater flexibility in application
- Greater adaptation, especially with respect to uncertain future projection decision making
- Possible dissociation of the future from the present (relatively speaking)

The disadvantages of simulation models are:

- Simulation does not eliminate imperfection of other models
- Some of the deficiencies in other models are partially addressed in the simulation models.

2.16 Other Classification Energy Models

Energy models can classified according to their ability to incorporate methodological frameworks, specially the link between energy sectors and microeconomic variables, energy end use analysis scenario building, and the evaluation of alternative policy options. The following classification looks at some of the advantages and disadvantages of energy models. [287]

- Simple extrapolation of past growth trends is commonly used in trend analysis based methodology of energy analysis. The disadvantage with this methodology is that the future is decreasingly like the past. It cannot model a structural change and does not allow for any energy-economy feedback.
- Multiple correlations forecasting energy model, is more sophisticated than trend analysis model. It establishes relationship between the past energy with other variables such as prices, income and future energy demand.

- Input – output analysis is a standard tool of qualitative analysis of the economic sector and can be extended and refined to model energy flows. Input – output analysis can be incorporated into econometric or simulation models, but the data requirement is considerable.
- Energy flow from primary sources of supply through to final demand, including transformation and conversion efficiencies can be considered as a process analysis of energy flow. Energy flows are recorded in physical units and process analysis thus provides a basic accounting framework. Its advantages are that it can provide different technology alternatives, enable optimisation of supply options, accommodate traditional fuels, and has relatively simple computing requirements. The main disadvantage is that energy-economy relationships and price and income demand elasticities are not an integral part of the model. An Example of this approach is the Long-range Alternative Energy Planning (LEAP) model.

2.17 Bottom up versus Top down models

The main characteristics of the model approach is that the energy system is defined by a limited number of technologies producing a single or well-defined physical output using distinct energy carriers as inputs. [288] In the model approach, energy system is defined by a limited number of technologies producing a well-defined physical output using distinct energy carriers as inputs. Parameters and variables are use to describe each category of these technologies

- efficiency
- availability
- technical life time
- emission factors

The "bottom-up" model approach is much less suited to describe the energy use in light industries that are producing goods, which can be aggregated into monitor terms or household energy, end use energy can be aggregated. This approach is not suitable when analysing the energy use that is most dependent on human behaviour. [289] On the other hand, the "top down" approach relies on mostly monetary variables and parameters estimated for long time-series of consistent national accounts statistics. It finds application in the econometric and macroeconomic analysis. [290]

2.18 Application of Energy Models in Uganda

There are several types of energy models used by different consultants in energy forecasting in Uganda that have been used over the last decade. In most cases there is no information on the type of software used. For instance, in 1996, the Uganda energy assessment was carried out by the World Bank. There was no information about the type of commercial software used.[291] In 1998, Electricity de France (EDF), carried out an optimisation study load forecast for Uganda.[292] They used PVDE software version 3.0.[293] In this study, Long-range Energy Alternative Planning, developed by the Stockholm Environment Institute was used because the model is versatile. LEAP is an energy model that covers energy demand, transformation and supply. It uses a simulation approach to represent the current energy situation for a given area and to develop forecasts for the future under different .The details of LEAP are found in the Appendix C.

CHAPTER THREE
THE PROBLEM STATEMENT

The previous chapter (Literature Review) reviewed literature related to the Energy Sector in Uganda. This Chapter describes the problem statement of the study.

The energy sector is a key factor in sustainable economic development. Thus, energy use and development must be put in perspective in all sectors of national development. However in Uganda, like in most developing countries, energy related decisions are taken before comprehensive policies are made. Further, Uganda relies on external funding for most of its policies. This inevitably compromises national interests. International consultants have conducted the bulk of the work in energy studies, while major developments are financed by foreign institutions, with limited local inputs.

Uganda is heavily dependent on its dwindling biomass resources for its domestic energy needs. The derived form of wood fuel, charcoal, is largely used in the urban areas while rural areas are dominated by fuelwood as the primary source of energy. Fuelwood consumption exceeds production in some parts of Uganda, resulting in pressure on the natural vegetation and causing soil erosion and silting as well as other environmental hazards like desertification and deforestation.

Fuelwood consumption is growing beyond sustainable limits. It is imperative that the present trend should be quantified and arrested to a sustainable limit so that Uganda does not become a desert in the future. The present data used in biomass studies is based on a population increase of 2.7 % per annum but the population has increased at a rate of 3.4 % per annum over the last decade. The last household energy survey was conducted ten years ago and there is a need to carry out another survey. Furthermore, there is increased use of fuelwood in industries. This implies that biomass consumption increase is over 3.5% per annum, if industrial and commercial uses of fuelwood are considered.

As regards electric power, studies conducted have shown that the generation capacity does not meet the national maximum demand. This has resulted in load shedding during both peak and off-peak hours. Current electricity production is insufficient to satisfy demand, thus stifling economic development. The result of insecurity of energy supply is that many firms have had to invest in stand-by power, especially diesel generators. As many as 77% of large firms, 44 % of medium-sized firms and 16% of small firms own a diesel power generator.[294]

Due to low levels of national electrification conditions, the population has to rely on firewood for cooking and kerosene for lighting. There is a need to compare the present electricity consumption with the projected demand made in the earlier studies in order to update the projected demand so that alternative electric energy supply options are taken into consideration.

Petroleum is the largest single imported product. The petroleum sector was liberalised before a comprehensive policy was put in place to ensure fair prices. It further appears that there is no mechanism in place to encourage practices that could lead to a reduction of fuel consumption in the country, either by efficient fuel usage or by its conservation. Moreover, petroleum importation requires large foreign exchange transactions and constitutes about 15% of the total imports. The transport sector, the largest consumer of petroleum products, uses 80 % of petroleum products. As the number of the vehicles increases, the oil bill will continue to rise.

The government has liberalised the petroleum industry and lifted all price controls on petroleum products. The initiative was taken without having a law in place protecting consumers against price fixing. A major consequence of high price fixing has been the increase in the incidence of petroleum smuggling, although the quantity of smuggled product is not known.

Until now, no study has been carried out to project the future petroleum energy demand. This study aims to address this deficiency. It further surfaces that most of the sources of alternative energy lack the basic infrastructure and energy intensities needed for development. With the exception of hydropower, where considerable scope for development exists, other sources of energy such as solar, biogas and wind energy could be used for low-power electrical generation, as well as cooking and water pumping in the rural areas not connected the to grid.

In the past, equipment using alternative sources of energy were in some cases installed in inappropriate locations. Furthermore, the recipients of the equipment were neither trained how to maintain the equipment nor did they receive basic education on its usage. The failure of the energy system could easily discourage future potential users of similar systems. The high up-front cost associated with installation of the alternative energy systems is a major problem. There is a need to find ways to reduce these costs and to initiate financial mechanisms to promote alternative energy and proper training procedures for technicians and users.

Most of the studies undertaken have focused on only one aspect of energy; either biomass or hydropower. The results of these studies are not available in a single document. It makes it very difficult for the policy makers to compile data and use them as a tool in their energy planning. Yet it is important to look at various alternatives and scenarios in parallel to understand the national energy mix. This study aims at filling the gaps identified in the problem statement.

CHAPTER FOUR
THE OBJECTIVES OF THE RESEARCH

Chapter Three described the statement of the problem on which this study was based. In this chapter, research objectives, significance of the study are dealt with. The next chapter is devoted to methodology.

The Objectives of the Research

The objectives of this research were to:

I. provide energy development scenarios that investigate a number of potential options for supplying Uganda's future energy requirements.

II. estimate future energy demand and identify optimum energy-mix systems and supply options for sustainable development in Uganda.

III. determine the impact of different types of energy use on the environment.

Significance of this Study

Future energy consumption patterns are driven by such elements as the GDP and population growth as well as the introduction of new, possibly more efficient technologies. It was therefore necessary to investigate trends and new developments in all the sectors of the economy, in order to make reasonable and accurate predictions of the demand for energy in the future. Government policies can have a large impact on future energy demand. For example, it is possible, using the energy model, to predict the effects of a nation-wide energy conservation programme.

Once the demand for energy is established for a particular scenario, it is possible to examine supply-side options that meet the demand. For example, is there merit in considering distributed electricity generation, and if so, what are the environmental and cost implications associated with the different options of say diesel and solar?

Since the model uses real energy and cost data, the results are defendable. This is important when having to make energy planning decisions in the face of sometimes very vocal, but possibly uninformed, pressure groups.

CHAPTER FIVE
METHODOLOGY

5.0 Introduction

This Chapter constitutes the methods that were used in this study. It examines data types and sources, sample selection, sample size, research instruments, and data analysis.

5.1 Data Collection

Various instruments were used in data collection. These included:

- Deskwork using handbooks, reports and records,
- Measurements and
- Questionnaires.

5.1.1 Data Collected by Desk work

Much of the data required for the energy model was available in the public domain, that is, Government departments and parastatals. This was because work in the energy field had been conducted by a number of international organisations, notably the World Bank and EDF. Consequently, a detailed picture of the supply and demand for energy in Uganda was assembled from published data, where available, and in the case of the domestic, commercial and industrial sectors from a survey that was conducted as part of the project. This data is used to manipulate the energy model in order to predict future demand from an accurate base line.

a) Electricity Generation and Consumption

The amounts of electricity generated by different co-generators and auto-generators were obtained from UEB and by visiting three sites of micro hydro plants and two of the three sugar producing industries in different regions of Uganda. Data on electricity consumption for domestic, industrial, commercial, street lighting and electricity exports were obtained from the UEB.

b) Gross Domestic Product and Other Economic Indicators

The GDP and the GDP per capita data were collected from 1990 to 1999. The contributions of different sectors of the economy to the monetary and non-monetary GDP were compiled. The main sectors under consideration were agriculture, industry, construction and transport. The population from 1990 to the present was considered. The population component and the GDP are necessary for computation of the GDP per capita.

c) Petroleum importation

Data was collected on the amount of petroleum products imported and the amount of foreign currency used to import fuel oil for the period 1990-1999. The number and types of motor vehicles imported were also considered.

d) Biomass

The data on land cover /land use were classified into twelve categories; plantation hardwood, plantation softwood, tropical high forest (normal), tropical high forest (degraded), woodland (tree shrubs), bush land, grassland, wetlands vegetation, commercial farmland, subsistence farmland, built up areas, impediment areas and water. The contribution of each of these types of land to the total biomass available for harvesting was obtained from the Department of Forestry, Ministry of Water, Lands and Environment.

5.1.2 Data Collected by Measurements

In some instances, reliable data was not available and in these cases, they were derived for this study. The first such data was the efficiency of wood stoves and to derive this data, a number of stoves were tested. Efficiencies of the ten most common charcoal stoves were measured in a laboratory. Most of these stoves are metal with ceramic linings. The water boiling test method was used to test the efficiencies of these stoves. It was also necessary to conduct a detailed survey of the current domestic energy usage patterns in both rural and urban areas. This necessitated questionnaires.

5.1.3 Questionnaires

In order to collect current data from various sectors, a number of customised, comprehensive and detailed questionnaires were designed for the research. A pre-test of the questionnaires was carried out in three schools and two industries at the beginning of the research. Changes suggested as a result of the pre-tests were accordingly incorporated into the final questionnaires. All the questionnaires were physically delivered and collected from the selected companies, industries and schools in the four regions (either by the researcher or by assistants).

A survey was conducted on the domestic energy consumption in both rural and urban areas in sixteen out of the forty-five districts in Uganda. The sixteen districts were selected from four regions in such a manner that they formed a representative sample in terms of population distribution and availability of woodfuel.

In the survey, students from selected secondary schools in four regions were used as assistants. In each of the secondary schools a teacher was nominated to co-ordinate the assistants. Students and the co-ordinator were trained on how to administer the questionnaires. Each student was given three questionnaires to administer. The total number of households surveyed was 966. This consisted of surveying 531 households from the rural and 435 households from the urban areas. The data collected included biomass, electric and kerosene consumption and the types of devices used in the households. The questionnaire is attached in Appendix D.

The data on industrial usage of fuel oil, electricity and biomass was collected from the main industrial towns of Uganda. Of the industries selected for study, ten were from Kampala, two from Tororo, four from Jinja, two from Mukono, two from Kasese and three from Rugungiri. Among the industries included were sugar, tea, tobacco, lime, cement, dairy, brewery, textile, steel and brick manufacturing. These are all industries with high-energy consumption. The data collected includes the production capacity and the forms of energy consumed. The list of the industries visited and the questionnaire used are attached in the Appendix E 1 and Appendix E Table E.2 respectively.

Energy usage in other sectors such as the parastatal sector was also involved. The National Water and Sewage Corporation was chosen as representative because it is the leading electricity-consuming government parastatal. Data on energy used in the sector, namely electricity, diesel and petrol, were collected. Results were subsequently collated for inclusion into the energy model.

Data were also collected from secondary schools and Makerere University. These include biomass, electricity and liquid petroleum gas (LPG) consumption. Ten schools and five halls of residence in the university were selected for study. The energy usage in institutions like schools and the University was obtained from the Domestic Bursars. The number of schools and institutions of higher learning in the country were obtained from the Ministry of Education and Sports.

5.2 Data Analysis

Responses were received for all the questionnaires from schools and most of the firms in all regions. The positive response was achieved after a thorough follow up of the questionnaires from industries. Secondary data were also obtained from relevant agencies and organisations like the Bank of Uganda, Ministry of Energy and Mineral Development, Ministry of Finance and Economic Development, British American Tobacco, Uganda Electricity Board and other sources.

The data collected was analysed to determine the classes of use, specific energy consumption and projection. Classification was done by sorting out the consumption into various groups/ sectors. The specific energy consumption was determined by getting the total amount consumed by the number of people or the number of items produced by that amount of energy.

Stoves Testing

The stoves were tested using a multi-terminal thermocouple, a balance and a stop watch and thermometer. The method used is based on the international standards produced by the Volunteers in International Assistance (VITA).[295] The thermal efficiencies of the stoves were determined.

5.3 Forecasting Indicators

Examination of the trends of energy consumption and GDP growth rates in the past 10 years were used to project future demand using forecasting method. In this case, scenario based method of focusing was selected over regular forecasting approach. The economic and social indicators were also used in the energy demand forecasting method. The GDP annual growth rate was the most important indicator used to reflect acceleration of economic development. The elasticity of energy consumption with respect to broad economic variables was also used in the demand forecast.

Biomass

The industrial growth rate with respect to GDP was used as the main driver. This is because the biomass is largely used in the domestic and industrial sectors. The future consumption of biomass depends on the demography and industrial production. As charcoal is mostly used in the urban areas, the future demand for charcoal is proportional to the rate of increases in the urban population. The growth in demand for charcoal in the commercial sector also depends on the rate of population increase and the price of charcoal.

Electricity

The growth in demand for electricity in the domestic sector was determined by the number of new connections per income category. The connections are expected to increase progressively due to the improvement in power supply and the rural electrification strategies. The rise in income and growth rates was used to predict the increase in the electricity consumption. The elasticities will vary over a period of time during the period of analysis. Industrial energy will increase with the shift in industrial production especially with the introduction of heavy industries.

The future load in all sectors depends on the price of electricity. The consumption of the other sectors was projected using the elasticities of the sector-wise power consumption to the relevant driver variables. The most resent electric energy demand forecast made by the EDF was compared with the research results.

Petroleum Products

The petroleum products are largely used in the transport, domestic and industrial sectors. Kerosene is largely used for lighting in the households sector. Future demand will depend on the increase in population income. The product of the vehicle-kilometres, depending on the type of the vehicle and kilometre travelled, determines the fuel intensity per vehicle. Growth rates in the person vehicle-kilometre were used to estimate the future demand for petroleum products in the transport sector. The vehicle-kilometre parameter was also used to determine the emissions from vehicles. The industrial demand was assumed to be proportional to industrial growth rate. The price elasticity of the fuel oil was also considered

5.3 Scenario Development

Three scenarios were developed namely; Status quo, Low Case , and Enhanced Scenario. The primary driving factors in the energy consumption of a country were GDP and population. Human resource development, political stability and poverty were among the secondary factors. The combination of these parameters was used to develop scenarios. The energy consumption trend was reflected in the scenarios. The data was fed into and analysed using the LEAP software. The final energy consumption mix was developed. It assumed that population growth will be maintained at 3.4 percent per annum.

5.4 Energy Demand Projections

Scenarios were developed using modelling techniques, which require energy demand forecast for all sectors of the Ugandan economy. The Long-range Alternative Energy Planning (LEAP) model was used. Energy demand projections are affected by the three main parameters that were used to develop the three scenarios. Parameters like contribution of different economic sectors to the economy and their elasticities were used to project energy demands. In the past, projections in the energy sector have mostly been made for twenty years. In this study the projections were made up to the year 2025.

CHAPTER SIX
DATA ANALYSIS

6.0 Introduction

This Chapter is devoted to analysis, interpretation, presentation and discussion of the findings. The presentation follows the research objectives earlier formulated for the study. In data analysis, 1999 was used as the base year.

Existing data indicates that the following sectors were the major users of energy: domestic, transport and the industrial sector. Consequently most effort was put into establishing, for these areas, the validity of data and where necessary initiating data collection programmes where data did not to exist. Besides the survey, efficiencies of the most common stoves were measured in the laboratory. Secondary data was also obtained from relevant agencies and organisations. The secondary data have limitations because in most cases it is not possible to be validated.

6.1 Data Quality

The quality of the data is important for it enhances their credibility. It increases the data's potential use. The quality can be lost through inadequate coverage, inaccurate measurements, inaccurate responses and data processing errors. Though however the funds available and time could not enable the author to use highly qualified numerators, the author paid attention to data quality management. Special measures were taken to ensure reasonable quality data. The included among others;

- Using a simple pre-tested questionnaire
- The country was divided in regions and then further subdivided into districts
- Selected good students in senior six and teachers were trained for one day how to fill questionnaire. The teacher's role was to assist and co-ordinate the students.
- Checking and editing questionnaires
- Verification that all data were entered into a computer
- Checking the consistency of the data with other data from other sources
- Questionnaires from industrial sector were filled by graduate engineers

- The researcher interviewed small scale industries and transport sector
- Cases where measurements were necessary, experiments were done at least five times then the data was averaged.

6.2 Domestic Energy Survey

The domestic sector is the leading energy consuming sector in Uganda. The most commonly used fuels are firewood in the rural areas and charcoal in the urban areas. These biomass fuels are used largely for cooking. Kerosene is mostly used for lighting. Electricity is used mostly for lighting in the low and medium income households.

The data collected included biomass, electric, LPG and kerosene consumption and the types of devices used in the households. The energy intensity for different households' activities was computed.

6.2.1 Households

In this survey, a household was defined as a group of people who normally live and eat together. The urban area is defined as a settlement with population of over 1,000 persons. In the base year, 1999, there were 4.27 million households in Uganda. The number of rural households was 3.71 million, which represented about 83 percent of the total households. The household size is smaller in the urban areas than rural areas as shown in Appendix B Table B6.1. The average household size is increasing both in the urban and rural areas. The western region has the largest household size with an average of 5.7 persons per household, while the central region is the lowest in the country with a household size of 4.8.

There has been an increase in the income in all categories as shown in Appendix B Table B6.2. The implication is that as people become wealthier, there will be an increase in the consumption of energy. The main increase is expected to be in the demand for kerosene and charcoal. Most of the wealthy households are found in the urban areas because most of the wealthy households are found there.

6.2.2 Household Energy Consumption

The domestic energy consumption was analysed separately for low income, medium income and high-income households in both urban and rural areas in the four regions of Uganda. The major sources of energy, woodfuel, charcoal, agriculture wastes, kerosene and electricity were initially analysed separately. Fuelwood and agricultural waste were treated as non-commercial fuels; charcoal, kerosene, LPG and electricity were treated as commercial fuel. Nearly all households use more than one type of appliance for cooking and lighting. As an example, charcoal stoves are commonly used for cooking while electricity and kerosene stoves are used for boiling water. Electrified households use kerosene and candles for lighting when there is load shedding. All the data were converted to joules in order to facilitate computation of the total energy consumption in different sectors.

Biomass

"Three-stone" stoves are the most common appliances used in rural households. Their efficiency is estimated at 9-11 %. "Three-stone" stoves were not very common in the urban households because of the smoke they generate. All-metal charcoal stoves were widely used in the urban households. The efficiency of these stoves was about 23%. The efficiency of the improved charcoal stoves was about 30% but they are not commonly used because of high cost and poor availability. The urban dwellers often cook on the veranda of their houses. Where cooking is done outdoors, emissions of gases are not a serious issue since the kitchen is well ventilated. In 1999, the total biomass energy consumption in households was 222.83 PJ.

Kerosene fuel

Most of the rural households used kerosene for lighting irrespective of their economic status, whereas in the urban areas, households depended on electricity and kerosene. Open-wick lamps, locally referred to as *'tadoba'*, were the most common appliances used for lighting in most of the households. Kerosene consumption was estimated according to the laboratory test of a *tadoba* (4.24 g/h), small hurricane lamps (10.2 g/h) and large hurricane lamps (13.75 g/h). The wick kerosene stove, which is used for cooking has a consumption of 117 g/h. The emission from a *tadoba* contains small particles of unburned carbon. It is evident from complaints raised that the soot from these is unpleasant. The use of solar photovoltaic for lighting is negligible and is limited to a few rich households. The total kerosene fuel consumption in households was 2.04 PJ in 1999.

Electricity consumption

Electrical appliances were identified in terms of use for air-conditioners, fans, electrical irons, washing machines, radios, TVs, refrigerators, cookers, kettles and vacuum cleaners. Most of households use 100W incandescent lamps for lighting. These lamps are readily available and cheap but have a low efficiency. There was little use of electric cookers and water heaters except in very wealthy households. Estimated monthly electric energy consumption per income category is illustrated in Appendix B Table B6.3. Electricity supply to the household sector is less than the demand. In the household survey, electricity consumption was 1.155 PJ, but the official data from the Uganda Electricity Distribution Company, was 1.11 PJ thus the difference was 4.5% higher than the official data.

LPG

There is increasing use of LPG among the high-income households. This fuel was not popular among the low-income households because the cost of appliances is high and the level of education and sensitisation about the use of LPG were low. The estimated consumption for LPG was 19 TJ in the base year.

6.3. Energy Consumption in Rural Households

Rural households were the largest consumers of energy. They rely largely on biomass for cooking. They have limited access to commercial fuel, apart from kerosene, which is mostly used for lighting. Total energy consumption for the rural households is 205.9 PJ. The detail per income class is found in the Appendix B Table 6.4. The detail of energy intensity per activity is shown in Appendix B Table B6.5.

Low income households

Low-income households accounted for 32% of the total population in the rural areas. They relied mostly on biomass for cooking and kerosene for lighting. They neither used kerosene nor electricity for cooking. Total biomass energy consumption was 62.3 PJ. Energy use for lighting was 182 TJ. Total energy consumption was 62.5 PJ.

Medium income households

Medium-income households were the largest group of the households, constituting about 49% of the total population in the rural areas. They rely mostly on biomass for cooking. The biomass consumption was 102.25 PJ. For lighting, they rely on kerosene and electricity, with an energy consumption of 645.7 TJ. They also used kerosene and electricity for cooking, consuming 68 TJ. The total energy consumption was 102.8 PJ.

High income households

The high-income households constituted 19 % of the total households in the rural areas. They used most of the energy sources available for cooking and lighting. The biomass consumption was 39.93 PJ. They use most of the commercial fuel for cooking and lighting with an energy consumption of 82.1 TJ and 570.7 TJ respectively. The total energy consumption was 40.58 PJ.

6.4. Energy Consumption in Urban Households

Urban households were the smallest consumers of biomass energy. The most popular fuel was charcoal for cooking. The urban households have a more favourable energy mix both for cooking and lighting. Total energy consumption for the urban households was rated at 20.28 PJ. The details per income class are found in Appendix B Table B6.6. The energy intensity per activity is as shown in Appendix B Tables B6.7.

Low-income households

The low-income households constituted 12% of the total households. The annual consumption of biomass was 2.24 PJ. Firewood was the main source of fuel for cooking followed by charcoal. The uses of commercial energy were limited to lighting, which was

17.8 TJ and for cooking was 0.57 PJ. Total energy consumption was 2.26 PJ. They do not use any commercial fuels for cooking with exception of charcoal.

Medium -income households

Medium-income households have more access to different sources of energy than low-income households. This group constituted 38% of the urban population. Biomass was the major source of fuel for cooking. The total energy consumption was 6.99 PJ. Commercial energy, used for cooking were kerosene, electricity and charcoal. Commercial energy consumption is 3.88 PJ.

High-income Households

50% of the urban households were high-income earners. They depend largely on biomass for cooking with limited use of electricity and LPG. The total annual biomass energy consumption was 9.44 PJ. The high-income households' used LPG for cooking only and the consumption was 18.9 TJ. The use of commercial energy for cooking was 7.68 PJ. Total energy consumption for lighting was 841.1 TJ. Total energy consumption was 10.97 PJ.

6.5 Results

6.5.1 Total Energy Consumption

The total household energy consumption in the base year (1999) was 226.34 PJ. The domestic and commercial sectors were combined, giving total energy consumption of 339.7 PJ of the national energy balance. Biomass constituted 98.6 % of the total energy consumption in households.[296]

The national data was based on the projection made by studies and available data. It is imperative to note that there has been no other comprehensive household energy survey carried since that of 1991 by CODA, whose results were rejected by the Ministry of Energy and Mineral Development. The data obtained in this study is a better estimate reflecting the household energy demand in the year 1999. It was also assumed that the overall population growth was estimated to be 2.7% per annum.

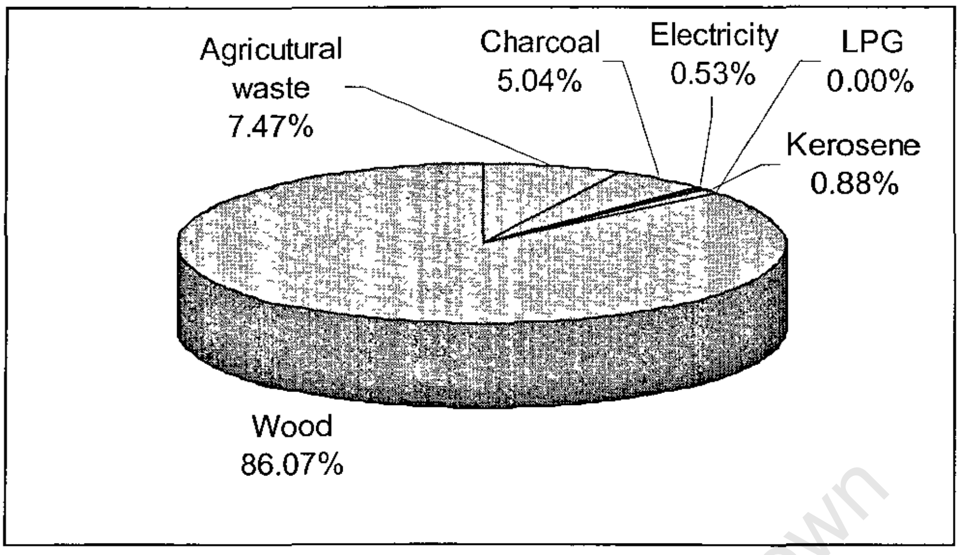

Figure 6.1: Composition of domestic energy consumption by percentage

Figure 6.1 shows that there is a high dependence on biomass (woodfuel, charcoal and agricultural residues). These sources of fuel are used for cooking. Total biomass energy consumption was 222.8 PJ and per capita biomass energy consumption was 9.93 GJ.

Commercial fuels (electricity and kerosene) are mostly used for lighting. In urban households, electricity is the most popular form of energy for lighting. However, it was limited in supply in both urban and rural areas. Biomass is the leading source of energy for households. Other sources of commercial energy contribute less that 2 % of the total domestic energy needs. LPG was mainly used for cooking. At national level, the use of LPG by the domestic sector is negligible. Kerosene was the most used commercial fuel for lighting in households. Commercial fuel consumption is 13.4 PJ and per capita commercial energy consumption is 597.1 MJ.

Energy Use for Cooking

Biomass is the most popular type of fuel in rural and urban areas. It is mostly used for highly energy intensive activities like cooking. While firewood is popular in the rural areas, charcoal was most popular in the urban areas. Agriculture waste was also one of the most important fuels used in the rural areas. Its use was higher than charcoal usage at the national level.

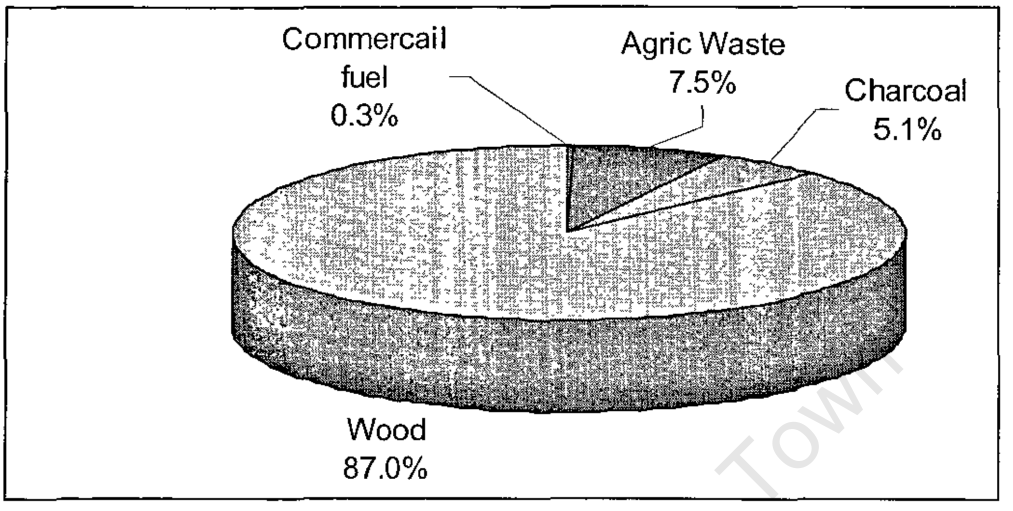

Figure 6.2: Use of energy for cooking in households .

The high dependence on firewood is a typical characteristic of developing countries. The use of commercial fuel for cooking is limited to very few wealthy households. The use of biogas is negligible and is limited to wealthy households with cows.

Energy use for lighting

The main sources of commercial energy are kerosene, electricity, and LPG. These forms of energy are used mostly for lighting. The use of LPG in lighting is negligible. There is a high dependence on kerosene as illustrated in Figure 6.3.

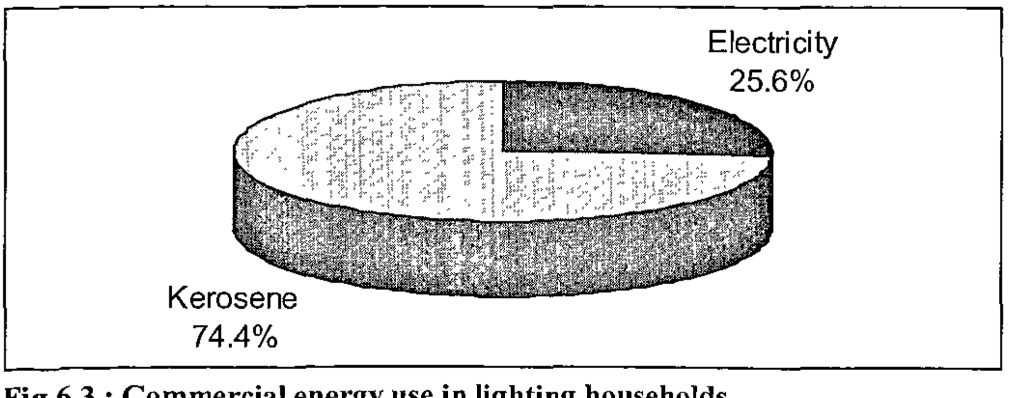

Fig 6.3 : Commercial energy use in lighting households

The total amount of energy used for lighting in households was 2.46 PJ. Kerosene is the most popular fuel with an annual consumption of 1.83 PJ, while the balance is electricity. The use of other fuels like grass and candles could not be quantified in terms of household energy use. The use of solar photovoltaic and biogas for lighting was negligible. Most of the electricity is used in the urban areas. The access of electricity in rural areas was less than 1%.

6.5.2 Energy Consumption in the Urban Areas

Most of the energy used in the urban households is for cooking and heating water. Charcoal is major source of biomass fuel in urban areas as shown in Figure 6.4

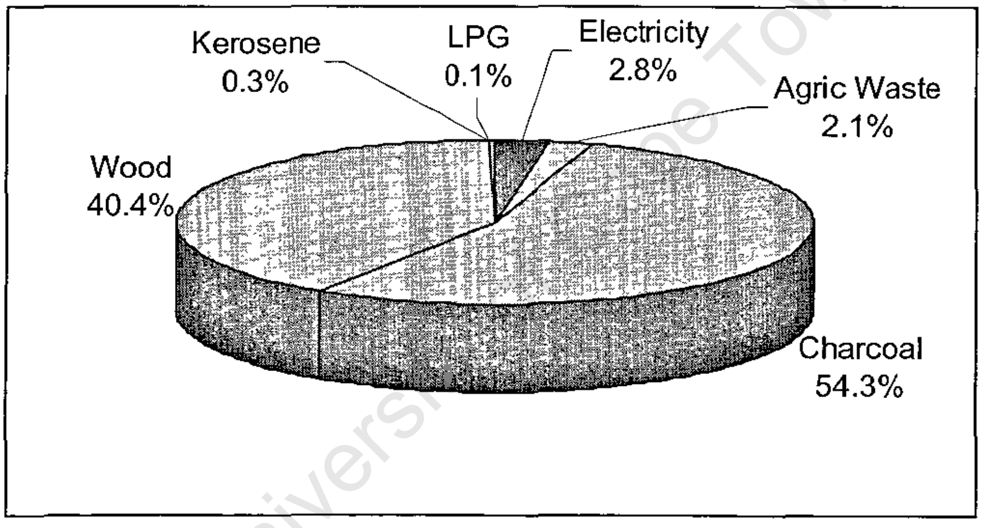

Fig 6.4 Energy sources used for cooking in urban households

Charcoal is a widely used commercial fuel in urban households because it is easier to store and it has a higher calorific value than firewood. The total energy used for cooking was 19.04 PJ of which charcoal usage was 10.34 PJ, while agriculture waste was least used (0.4 PJ). The urban low-income group used firewood and agriculture wastes. The wealthy households use commercial fuel for cooking and operation of household's appliances. The energy mix for urban households is composed of biomass and commercial energy.

Electricity was the most popular source of energy for lighting in urban households. There was wide use of kerosene in the urban households because of persistent electricity load shedding in the urban areas. The use of kerosene lamps was limited to 3-4 hours a day(Figure 6.5) The high usage of kerosene will continue if the electric demand continues to increase.

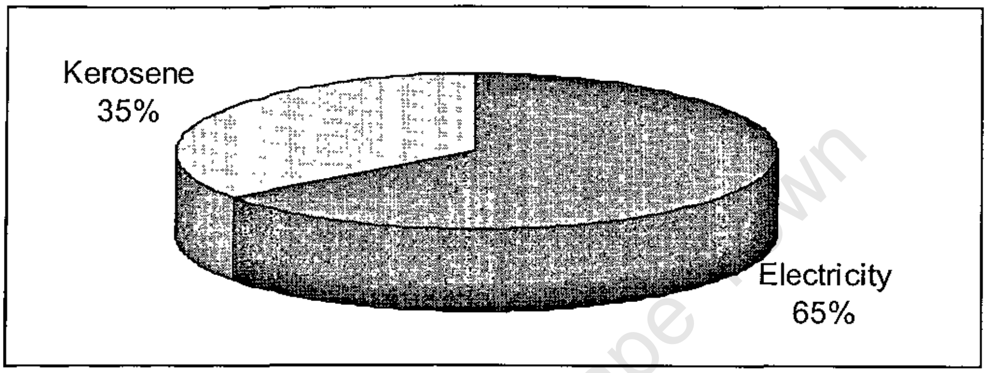

Figure 6.5: Commercial energy use in lighting urban households

The total energy used in lighting was 1.06 PJ. Electricity usage was 0.546 PJ. With the increased supply of electricity, its share is expected to increase and the use of kerosene expected to decrease.

6.5.3 Energy Consumption in the Rural Areas

Most of the energy used in rural households is for either cooking or lighting. Biomass is the major energy source for cooking, while kerosene is the major source of energy for lighting.

Energy use in Cooking

The most common source of energy for cooking in the rural areas is firewood. It was the cheapest source of energy. There was little commercialisation of wood fuel in the rural areas except for the medium and high-income households. The total energy used for cooking was 204.54 PJ. Firewood was the leading source of energy contributing 186.87

PJ, while commercial fuel was least used contributing 1.2 PJ. Charcoal usage in the rural households was expected to increase if the income of the rural households increases and the distance travelled to obtain firewood increases.

In most cases firewood was collected within 1-2 kilometres from the households. As the population increases more land will be cleared for agriculture. As more land is cleared, the firewood source will be made to be far from the households. The rural households depend almost entirely on biomass as shown in Figure 6.6.

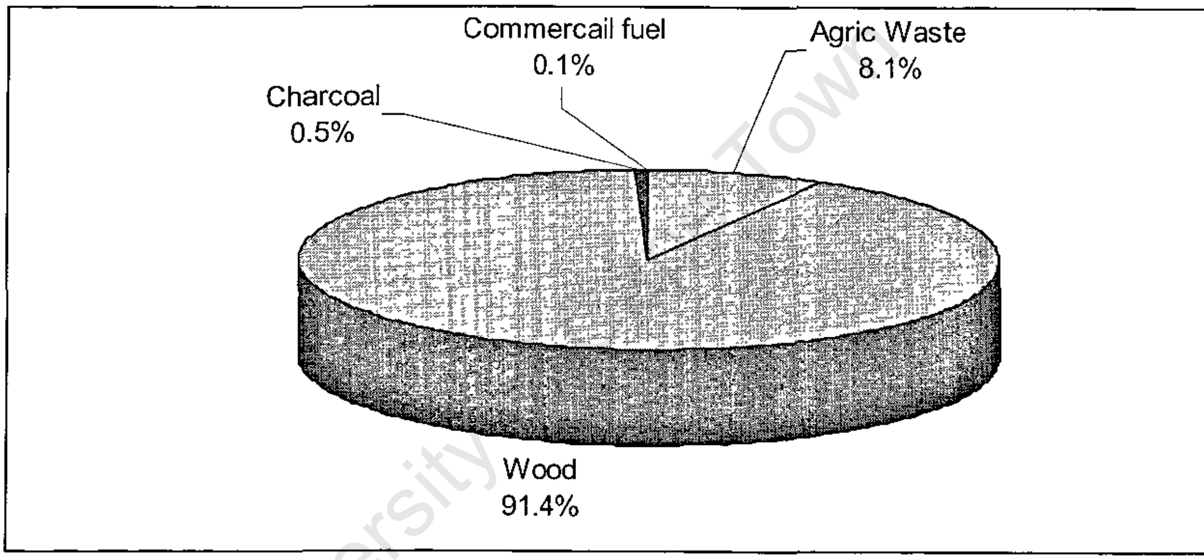

Figure 6. 6 : Energy use in rural households for cooking

Energy use in lighting

Kerosene was the major source of lighting in rural households. The low income and medium income households used "*tadoba*" for lighting. The high-income households and some medium-income households used hurricane lamps. The use of other appliances such as pressure lamps was negligible. The total energy consumption was 1.398 PJ, of which electricity contributed 5.7 TJ. This illustrates the low level of electrification nation-wide. No major increase in electricity consumption was expected in the rural areas because of the government policy requires that implementation of rural electrification must be based on cost recovery. The contribution of different commercial energy sources to lighting in the rural households are as shown in Figure 6.7.

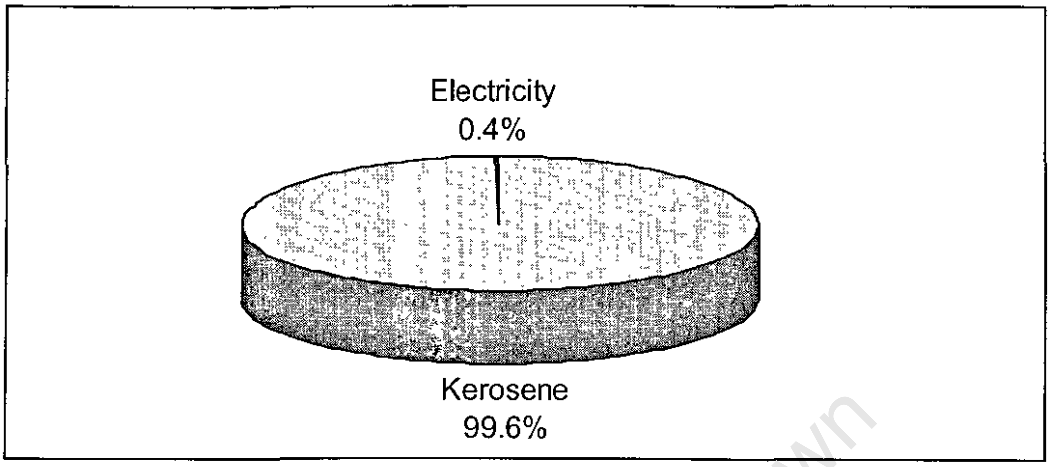

Figure 6.7 Commercial energy use in lighting rural households

6.5.4 Per capita Energy use in Households

It is imperative to note that the access to energy and its use is affected by the income and location of the households (rural or urban). All categories of households use mainly biomass for cooking. However the rich households have access to electricity and other commercial fuels.

Rural households

Low-income households have limited access to commercial energy sources. They relied on biomass in the form of firewood and agricultural waste for cooking. The per capita biomass energy consumption is 8.54 GJ. The households also use kerosene grass and candles for lighting. The per capita commercial energy for lighting was 24.94 MJ per annum.

The medium and high-income households had access to more sources of energy. Medium and high-income households' per capita biomass energy consumption is 9.42 GJ and 9.26 GJ respectively per annum. It is imperative to note that the results fall within the range of surveys made for countries in the region in which per capita biomass energy consumption in the rural households lies between 7.5 GJ and 11.4 GJ per capita per annum. [297]

The per capita commercial energy consumption of medium and high-income households for lighting and other household electrical appliances was 154.9 MJ and 257.4 MJ respectively per annum. There was a large difference in use of commercial energy consumption in all the three categories. High-income households used more commercial fuel than other categories because they use light for more hours and possess more household appliances.

Urban households

Low-income households had less access to energy sources for cooking. They relied on firewood, charcoal and agricultural waste. The per capita biomass energy use was 6.4 GJ. The per capita commercial energy use was 1.85 GJ per annum. Medium- and high-income households' per capita biomass energy consumption was 6.09 GJ and 6.47 GJ respectively per annum. The per capita commercial energy consumption for medium and high-income household for lighting and other household electrical appliances is 213 MJ and 1.12 GJ respectively per annum. The medium- and high-income households had more access to commercial energy. High-income households used light for more hours than other categories. This confirms that as income increases there is a corresponding increase in energy consumption.

6.5.5 Other Sources of Electric Energy for Households

The use of renewable energy in households is limited to the high income households. Most of the photovoltaic systems are used for lighting and in few cases used for television. In the rural areas 3.8 % of the high income households have PV with 50 Watt peak capacity, while 1.3 % of the households in the urban areas, use the average capacity of 75 Watt peak capacity. The estimated number of photovoltaic systems in household was 29,440 units.

The medium and high income rural household use 12 Volts car batteries as their main source of electric energy for household appliances. The appliances included radios and black and white televisions. 5% of the high income and 7.5% of the medium income used car batteries. Use of car batteries was also common in the medium income house holds. It was estimated that 10% of the households use car batteries as the main source of electricity. 360,500 household estimated to be using car batteries in both the rural and urban areas.

6.6 Testing efficiencies of Stoves

Tests on the efficiencies of stoves were carried out as part of this study. The main purpose of testing the efficiency of the stoves was to determine the comparative performance of improved and traditional stoves. The tests were also intended to determine potential and expected fuel savings offered by improved stoves.

Five tests were carried on each stove of the selected ten stoves. The descriptions of the stoves and the average efficiency for each of the stoves are presented in this section as follows:

Description

- Stove No.1 is an improved charcoal stove (USIKA). It has an inverted truncated cone and a bell-bottom shaped metal structure with ceramic lining and vermiculite cement layer between the ceramic insert and the metal cladding. It has three pot rests and a hinged door. Its weight is 3.43 kg, a pot-hole diameter of 2.4cm and an average wall thickness of 3.5cm.
- Stove No.2 is an improved charcoal stove with an inverted truncated cone and a bell-bottom shaped metal structure with ceramic lining like the USIKA type but does not have a vermiculite cement layer between the ceramic insert and the cladding. It has a weight of 5.39 kg, pothole diameter of 19.8cm, an average wall thickness of 3.6cm, 3 pot rests and a hinged door.
- Stove No.3 is a traditional charcoal stove, all made out of clay and cylindrical in shape. It has got two metallic strips and six exhaust holes of diameter 2.3cm around

the combustion chamber to assist with combustion and at the same time enhance space heating. Its primary air inlet does not have a shutter. Its grate has got horizontal perforations covering about 20% of the grate area to allow for under grate air. It has a weight of 5.74 kg, pot hole diameter of 24.3cm and an average wall thickness of 1.4cm.

- Stove No.4 is a traditional stove commonly known as the Kabale stove. Its structure consists of an inverted truncated cone made out of fired clay. It has 3 triangular exhaust holes around the combustion chamber to assist with combustion and at the same time enhance space heating. Its primary air inlet is without a shutter. It has a weight of 3.60 kg, pot hole diameter of 17.8cm and a grate with 4 horizontal perforations covering about 2% of the grate area. The pot rests, handles and legs are all made of clay
- Stove No.5, is an improved charcoal stove. It has a truncated cone and a bell-bottom shaped metal structure with ceramic lining and a vermiculite cement layer between the ceramic insert and the metal cladding. It has 3 pot rests, a hinged door, a weight of 2.7 kg, pot hole diameter of 25 cm and an average wall thickness of 2.8cm. It is similar to No 1, but lighter than No.1.
- Stove No.6 is an improved charcoal stove (black power). The metal structure has a cylindrical shape with a ceramic lining and three primary air inlets without shutters. It has a weight of 13.45 kg, a pot hole diameter of 23.0cm, 21 grate holes of diameter 1.9cm and an average wall thickness of 3.2cm. The pot supports are made from cast iron.
- Stove No. 7 is an improved charcoal stove. It has an inverted truncated cone shaped metal structure with ceramic lining. It has 3 triangular exhausted holes around the combustion chamber and a primary air inlet with out a shutter. It has a weight of 4.043 kg, a pot hole diameter of 19.6cm, 3 horizontal grate perforations covering about 25% of the grate area and an average wall thickness 2.1cm.
- Stove No.8 is an improved charcoal stove. The metallic structure has a cylindrical shape covering the entire ceramic lining. It has 3 pot rests, 2 handles, 3 legs and one primary air inlet with a door opening from both sides. It has a weight of 7.71 kg, a

pot hole diameter of 19.6cm, 13 grate holes of diameter 2.3cm and an average wall thickness of 4.1cm.

- Stove No.9 is an improved charcoal stove. The metallic structure has a cylindrical shape covering the entire a ceramic lining with 3 pot rests, 2 handles and 3 legs. It has a weight of 6.33 kg, a pot hole diameter of 20.6cm, 19grate holes of diameter 1.7cm and an average wall thickness of 3.6cm
- Stove No.10, is a traditional metallic stove (sigiri). It is made out of scrap sheet metal obtained from discarded motor vehicles or used metal drums. The *sigiri* has a cylindrical shape with three pot rests, two handles, a grate and an adjustable hinged door. It has 3 triangular exhaust holes around the combustion chamber to assist and at the same time enhance space heating. It has a weight of 2.25 kg, 8 irregular grate holes covering about 30% of the grate area. It has a pot hole diameter of 26.5cm.

Three basic methods of testing the efficiency of stoves are used worldwide; the water boiling test, controlled cooking test and kitchen performance test.

The water boiling test is a simulation of a standard cooking procedure. The study was carried in two phases, the low power and high power phases and the overall efficiency computed based on the results of the two phases.

The water boiling test is a simple simulation of standard cooking procedure. It is the most common method used for stove testing. In this research, water boiling was used as the method of testing the efficiency of stoves. The tests were carried out at low and high power phases. The high power phase involved boiling a standard quantity of water from ambient temperature to boiling as rapidly as possible. The temperature of the water was recorded after every five minutes until water begins to boil. As soon as water begins to boil, measurements of the charcoal and water in the source pan were taken. That completed the high power phase. In the low power phase, the primary inlet air was closed to reduce the power. The water was allowed to simmer for 30 minutes.

After the low power phase, the charcoal and remaining water was weighed. The amount of charcoal consumed during the low and high power phase was computed. The results were entered in the Table shown in the Appendix F Table F6.1. The equations used are as illustrated in Appendix F Table F6.2

In the kitchen performance test, normal cooking practice was observed during the period of study. The cooking is observed when using traditional stoves and improved charcoal stoves. The test determines relative fuel consumption and demonstrates efficiency of fuel saving potential in the households.

The controlled cooking test was designed to compare cooking on different stoves and to determine whether the stove can cook a range of meals normally prepared. A local meal is prepared using local foods, cooking methods and fuel but under controlled condition.

The Test Results

The burning rate, specific fuel consumption, overall efficiency and power output from the stoves are tabulated in Appendix F Table F6.3. The most efficient stove was Black Power stove no.6. It has a general efficiency of 35.44 % and power output is estimated to be1.8 kW. It is the heaviest of the ten stoves. It has three air inlet doors without shutters. There are other stoves with nearly similar efficiency such as stove no. 2 and no.5. In general these two types of stoves are similar in design but with small variations. It is common to produce copied stoves in Uganda.

The stoves with small air inlets and few grate holes normally take longer to boil water. The traditional metal stove was the most commonly used stove. It was the cheapest stove available in the market. Its overall laboratory efficiency was 22 %. Stove no. 9 is a ceramic stove but due to its poor design, its efficiency was only 2% higher than that of a traditional metal stove.

During the Household Energy Planning Programme, CODA and Partners carried out studies of efficiencies of domestic stoves in Uganda.[298] They did not conduct low power phase tests. As the result the efficiencies of the stoves were lower. In this research both low and high power phases were considered. Therefore these tests are more representative than those carried out during the Household Energy Survey.

6.7 Energy Use in Industrial Sector

The major sources of energy in the industrial sector were biomass, electricity, and petroleum. Uganda has a low rate of industrialisation. This was confirmed by the fact that the manufacturing and industry contribution to the total GDP is less than 8.6 %, and the estimated growth rate for 1999/2000 was 2.4%. [299] Unreliable electrical energy supply and the high cost of petroleum were some of the major constraints of the industrial sector development over the last decades.

The data on the industrial sector use of fuel oil, electricity and biomass was collected from selected industries with high energy consumption. Specific energy for different commodities was computed. Besides the large industrial energy users, there were many small-scale industries, most of which were low energy consumption, characterised by the inefficient use of energy.

6.7.1 Manufacturing and Industry

There has been a decline in the manufacturing sector over the last three years. One of the reasons is the worsening terms of trade and high taxation, coupled with high energy costs. Most of the manufacturing sector provides goods for the domestic market but relies heavily on imported inputs. As a result, real exchange rate depreciation reduces profitability in the sector. Stiff competition from importers of similar goods and lack of international competitiveness in the local manufacturing sector are some of the causes of the decline. Worsening terms of trade further imply that there are very limited opportunities to export products into the international market.

The annual percentage change in the industrial index decreased from 12.4 percent in 1999 to 3.4 percent in 2000. [300] The sectors that were most affected were coffee processing, tobacco and beverages, textile and clothing as well as steel and steel products. The other sectors, including sugar production, food manufacturing and bricks and cement had increases in their indexes. The production indexes are illustrated in Appendix A Figure A6.1. The index of industrial production annual percentage change decreased from 3.33 percent in the year 2000 to 2.14 percent in 2002.[301]

Classification of Industries

The industrial sector can be divided into large, medium and small-scale industries. However, classification is not uniform. If a company has assets valued at more than US$ 500,000, the Ministry of Industries Tourism and Trade classifies it as a large-scale company. For medium-scale companies, the assets fall between US$ 100,000 and US$500,000. A small-scale industry has assets valued at less than US$100,000. On the other hand, the Uganda Electricity Board classifies industries according to the maximum power demand in kVA. Industries with a maximum demand of over 500 kVA are classified as large-scale users while, if the maximum demand is 500 kVA or less, they are classed as small-scale users.

6.7.2 Energy use in Industries

The national energy balance for 1999, indicated that the industrial energy use for 1999 was 18.14 PJ.[302] The contribution of the different sources of energy in 1999 and 2000 is shown in Appendix B Table B6.8.

The highest increase was electric energy consumption by the industrial sector. The increase in electricity was about 20%. The total industrial energy increased by 3.7 %. The availability of electricity could be one of the contributory factors to the increased industrial production index discussed in section 5.6.1. The contribution of different sources of energy use in industrial sector for the year 1999 is as shown in Figure 6.8.

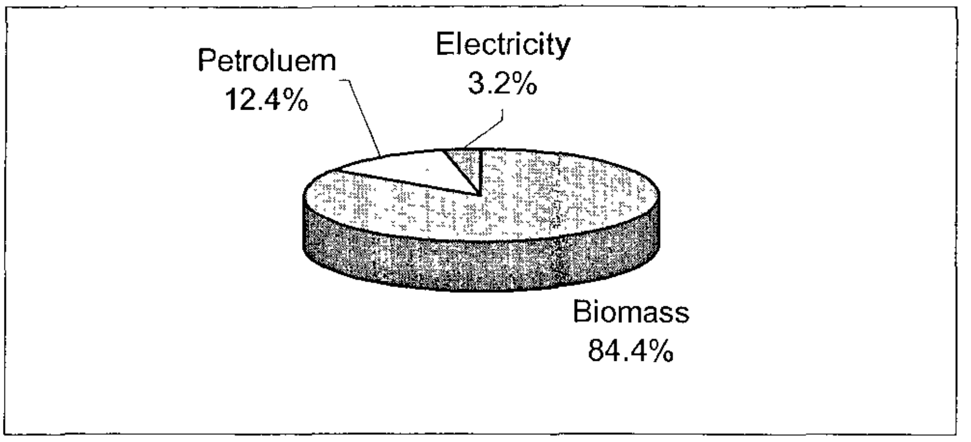

Figure 6.8: Energy use in industrial sector 1999

Figure 6.8 shows that biomass is the leading energy source for industrial production. The importance of biomass in the industrial sector did not change in 2000. Biomass contribution in 2000 was 85.4%, petroleum 10.7 % and electricity 3.9 % .[303] In this study, the total energy consumption for both small scale and large scale industries was 16.6 PJ. The composition of energy mix in 1999 (base year) was biomass 84.4 %, petroleum 10.8% and electricity 4.8%.

Biomass

Biomass is the leading source of energy used in industries. There is a growing demand for biomass resources because of the economic recovery that has taken place over the last decade. Biomass is a favourable fuel of small-scale industries. Firewood is used in the following sectors; lime, tobacco, tea, jaggery, fish, brick and tiles. Firewood is mostly used in drying, firing, heating and other thermal processes. It is estimated that 19.2 PJ was used in the industrial sector in 1999, while for the year 2000 it was 16.32 PJ.[304] In this study biomass energy use in the industrial sector was estimated to be 14 PJ in the base year 1999. The difference was due to the over estimate made in the lime industry.

Petroleum

Petroleum products are commonly used in boilers for steam production in process industries and power generation. It is the main source of energy used in the production of clinker in the cement industry. Other industries use furnace oil for steam generation. The largest users are the textiles and breweries industries.

In the remote areas, diesel generators are used to run agro-processing industries like coffee, tea processing industries and ginneries, while in areas that are connected to the grid, they are used as a standby power supply. The consumption of industrial fuel oil decreased from 1.60 PJ in 1999 to 1.22 PJ in 2002.[305] There was a decrease in use of petroleum products due to the increase in prices coupled with the weakening of the Uganda Shilling. This is illustrated in Appendix A Figure A6.2. The price of petroleum did not decrease following liberalisation of the petroleum sector.

Electricity

Electricity consumption in the industrial sector rose from 0.59 PJ in 1999 to 1.70 PJ in the year 2002 [306]. The total electricity generated in year 2000 was 5.54 PJ. About 56 percent of the total industrial energy was consumed in the Kampala area. There are 10 industries; listed in Appendix B Table B6.9. The ten industries consume about 0.6 PJ. This is about 80 per cent of the industrial energy consumption. [307] The three leading electric energy-consuming industries are the Hima Cement Factory, Steel Rolling Mills and the Sugar Corporation of Uganda. Electricity is mostly used as a prime mover for machinery and equipment in industries.

There were increases in the tariff in June 2004. The retail tariff for the period 1993 to 2004 [308] is as shown in Appendix A Figure A6.3. The present electricity tariff based on maximum demand in kVA is illustrated in Appendix B Table B6.10.

Generally the industrial tariff is lower than the domestic and commercial sector's tariff. This encourages industrialisation. There was continuous revision of tariffs. The increasing price of electricity is likely to have a negative impact on industrial production. High electric energy consuming industries should seriously consider energy conservation and energy management techniques.

6.7.3 Large Scale industries

a) Cement Industries

Cement production is an energy intensive process that produces significant quantities of greenhouse gases and consumes substantial raw materials. The cement production plant consists of the following three processes; raw material processing, clinker burning and the grinding process. Fuel oil is the main source of energy for clinker processing, while other processes need electricity to run equipment.

There are two cement factories in Uganda. The total production is 347,274 tonnes. [309] This satisfies only about 80 % of the national need. Cement is imported from neighbouring countries such as Kenya and Tanzania.

Tororo Cement Factory

The energy used in clinker production for the period 1997-1999 is as given in the Appendix B Table B6.11. The low rate of production often leads to high fuel consumption. The fuel oil consumption for 1998 was 1.652 TJ. Fuel oil is the major form of energy in the Tororo Cement Factory as shown in Figure 6.9.

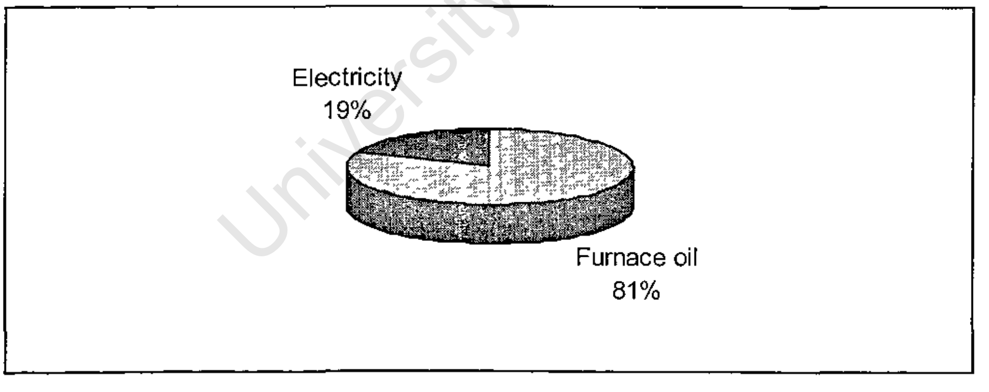

Figure 6.9 : Energy sources in Tororo Cement Factory

As per figure 6.9 above, the specific energy consumption for the Tororo Cement Factory was 6.11 GJ per metric tonnes of clinker produced. It is comparable with similar cement industries in India, which lie between 3 - 7.6 GJ per tonne.[310] The variation in specific energy consumption is shown in Appendix A Figure A6.4. Electric energy consumption is 1.170 GJ per metric tonne of clinker produced. Comparatively the average specific energy consumption for cement production is 3.67 GJ per tonne in Japan.[311]

The specific energy consumption is illustrated in Appendix B Table B6.12. An analysis should be made to establish where energy conservation measures could be introduced in light of recent tariff increases. Most of the equipment in the factory is old. There is growing market for cement especially in the construction sector.

Hima Cement Factory

Hima Cement is the second largest cement industry in Uganda. The cement production was 173,612 metric tonnes in 1999, while in 2000 the production was 172,076 metric tonnes. The forms of energy used in this industry include industrial fuel oil for clinker burning and electricity for running equipment. The contribution of the energy sources is shown in Figure 6.10.

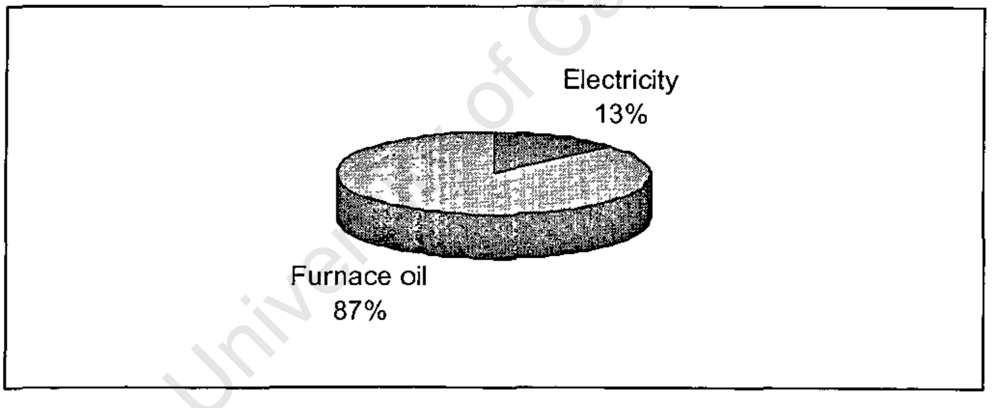

Figure 6.10: Main energy resources in Hima Cement Factory

Furnace oil is the major form of energy in the processing of cement at Hima Cement Ltd. The cement production for the years 1999-2000 are shown in Appendix A Figure A.6.5 The average specific energy consumption was estimated at 4.44 GJ per metric tonne of cement. Electric energy consumption is 0.565 GJ per metric tonne of cement produced. The value is higher when compared with Indian cement factories, range between 0.31 and 0.51 GJ per metric tonne [312] as shown in Appendix B Table B12.

b) Steel

Steel is one of the most energy intensive industries in Uganda. The Steel Rolling Mills produces steel out of scrap metal. They use electric arc furnace to melt steel scrap. The steel produced is generally used for structural construction and reinforcement. The steel is cast into ingots and then rolled to produce the needed profiles. Most of the process is still manually operated. The specific energy consumption is estimated at 5.67 GJ per metric tonne. The electric energy consumption is 2.19 GJ per metric tonne. The factory used furnace oil for low temperature heat treatment of steel. The thermal energy in the form of fuel oil was 3.534 GJ per tonne of steel produced. The details are illustrated in the Appendix A Figure A6.6. Despite the high electric energy use, the factory does not have power factor correction. It would improve on the conversion of the current into useful output, thus increasing the efficiency.

c) Sugar Industry

There are three major sugar industries in Uganda namely, Kakira Sugar Works (1985) Ltd, Sugar Corporation of Uganda Limited (SCOUL), and Kinyara Sugar Works. The sugar industries are among the major consumers of biomass in the form of bagasse, and electric energy in Uganda. The total production in 1999 was 126,937 tonnes.

The sugar industries use bagasse for steam generation. On average, the production of bagasse is estimated at 3.35 tonnes of bagasse per ton of sugar produced. The bagasse production was 425,238 tonnes in 1999. The total energy from the bagasse was 3.28 PJ. Of the three sugar companies, Sugar Corporation of Uganda Limited (SCOUL) was studied as part of this project.

Sugar Corporation of Uganda Limited (SCOUL)

SCOUL is the second largest sugar-producing factory in Uganda. The main sources of energy used in sugar processing include electricity, biomass and furnace oil. Fuelwood is used only when lighting bagasse. The contribution of different energy sources used in sugar production as shown in Figure 6.11.

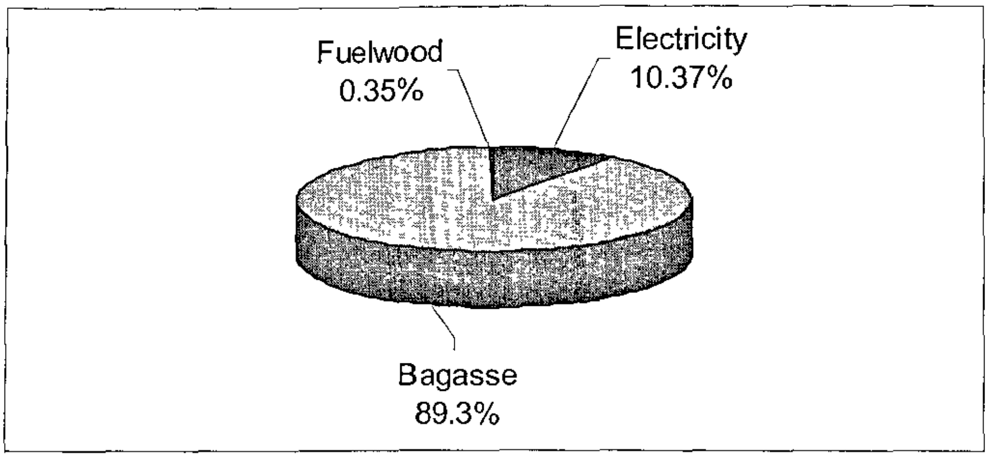

Figure 6.11: Sources of energy in sugar production

The data for sugar, bagasse and molasses production and specific energy consumption from January 1997 to August 1999 is presented in Appendix B Table B13. The average specific energy consumption over the same period was 27.04 MJ per kg of sugar produced. The consumption is illustrated in Appendix A Figure A6.7 The factory uses 75% of the bagasse for steam and electrical generation. The rest of the bagasse is burnt.

Kakira Sugar Works

Kakira Sugar Works (1985) Ltd currently crushes about 2,500 tonnes of cane per day and produces about 2.6 MW of power from excess bagasse which is not utilised in running the sugar factory.[313] In 2000 the factory purchased 6.52 TJ from Uganda Electricity Development Company Limited. The factory is planning to crush 3,000 tonnes cane per day (TCD). The factory plans to expand its milling capacity to 5,000 TCD. For the processing rates of 5,000 TCD, the annual export power to Uganda Electricity Transition Company is expected to reach 136.5 GWh. The maximum generation output would then be 26 MW, of which about 18 MW will be sold to Uganda Transmission Company Ltd. and the factory will consume the balance.

d) Dairy industries

There are four dairy industries in Uganda, three of which are located in the Western region. The GBK Dairy Products (U) has a production of 95,000 litres per day. The diary has 25 collecting centres in Mbarara. The Country Test factory has a capacity of 30,000 litres a day. The largest dairy plant, Dairy Corporation Limited is in Kampala.

Dairy Corporation Limited

Milk production in Uganda is estimated at 26.5 million litres per annum.[314] Uganda Diary Corporation is the leading producer of diary products in Uganda. The milk processing plant is over 30 years old. It processes about 59 percent of the milk produced in Uganda. The main source of milk is over 200 km away from Kampala. The main products are cheese, fresh milk, butter and ice cream. The major energy consuming equipment are two boilers with a steam production capacity of 1100 kg/h, two pasteurizers, two generators of 250 kVA each and fleet of 10 lorries. The forms of energy used in the industry are diesel, furnace oil and electricity. The contributions of the energy forms are given in Figure 6.12.

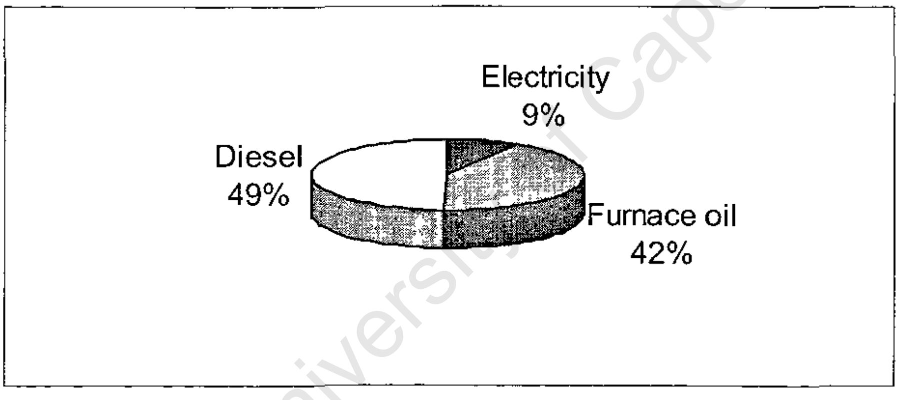

Figure 6.12 : Energy Usage by Dairy Corporation Ltd

Diesel is the leading source of energy in the company. Diesel is used for both transport and generators. The transport section needs further study to see if there could be a reduction in energy use.

The amount of milk processed and specific energy consumption for the year 1999 is given in Appendix A Figure A6.8. The specific energy consumption for the processed milk is 0.66 MJ/kg. In most of the dairy processing plants, the total specific energy consumption is within the range of 0.5 to 1.2 MJ/kg. The modern milk processing plant with high efficiency regenerative pasteurizers and modern boilers, the specific energy consumption is 0.34 MJ/kg.[315] At the international level, the power factor of milk processing plant varies between 0.8 to 0.9, but for the Dairy Corporation Ltd, the power factor is between 0.4 and 0.5, which is very low.

e) Bricks and Tiles

There are a few medium scale industries that produce bricks and tiles using coffee husks. It was estimated that 70 percent of the houses in the urban area use fired bricks in construction. The estimated growth in the number of households was about 110,000 per annum. Typical medium-income houses in the urban are estimated to cost 7,000 bricks, while for high income housing the estimated cost was 15,000 bricks.

The medium-scale companies relied mostly on coffee husks as the main source of thermal energy. The major tiles and brick making industries were Uganda Clays Ltd, Pan African Clay Work Ltd and Allied Clay and Works Ltd. All these factories are located within 15 km of Kampala City. The estimated demand for bricks and tiles in the major cities like Kampala, Jinja and Entebbe is 52,500 tonnes a year. The brick making factories relied on a small amount of firewood for starting up the kilns, and on coffee husks and furnace oil. The total energy consumption was 108.8 TJ of which 77.4 TJ was coffee husks. Uganda Clays Ltd is the largest producer of bricks and tiles and consumes 56.6 TJ of coffee husks a year. The specific energy consumption of the brick and tiles industry is given in Appendix B Table B6.14.

There were large variations in the specific energy consumption in the brick and tile industries. Only Uganda Clays Ltd, with a specific energy of 1.482 MJ/kg, was open and readily gave the data. Pan African Clay Works seemed to be on the high side with 2.662 MJ/kg. It's annual production was one third of Uganda Clays Ltd. There was concern over the decline in the availability of coffee husks. Husks are also used for mulching in farming.

Kiwa Industries produces concrete tiles. The energy is only used during the curing of concrete tiles. The price of a concrete tile is 15% lower than clay tiles and its production does not consume a lot of energy. Furthermore it is environmentally friendlier. With the increasing scarcity of biomass, concrete tiles are likely to become more popular.

f) Beverages and Breweries

Breweries are among the leading energy consumers in Uganda. There are two breweries in Uganda, Nile Breweries and East African Breweries. Most of the energy is in the form of electricity for driving the processing machines and for the furnace oil for the boilers. Boilers are mostly used for steam production, which is commonly used in the processing section. Among the high energy consuming areas are steam generation, refrigeration and air compression systems and the CO_2 recovery plant. In 1999, the total beer production was 1.17 million hectolitres.

Uganda Breweries Ltd

Uganda Breweries Limited is the leading brewery company in Uganda. The production is about 650,000 hectolitre per year. Boilers use 81.1 % of the total energy consumed in the company in the production of steam. The steam is used for wort boiling, bottle washing and pasteurisation. The total electric energy consumption is 31.8 TJ per annum. Electricity is used to run pumps, the refrigeration system and is also used for lighting. The consumption of electricity is estimated to be 48.96 MJ /hl. The fuel oil consumption is 2,595,708 litres per month. The specific energy consumption is 201 MJ/hl for fuel oil. The specific energy consumption for heat in modern breweries is 125 MJ/hl, and specific electricity consumption is 36.65 MJ/hl. [316]

Century Bottling Company

Century Bottling Company is the leading soft drinks producer in Uganda. It is the producer of Coca-Cola products in Uganda. The average production is about 457,500 hl/year. The boilers are used to produce steam. Thermal energy is utilised extensively in washing bottles. Thermal energy consumption is about 0.6 TJ per year. The electricity consumption is 28.26 MJ/hl, while in most European countries it is about 12.96 MJ/hl.[317] The differences could have been partly due the ongoing construction at the site.

g) Tobacco Processing Plant

The British American Tobacco Company (BAT) has two tobacco processing plants in Uganda. The largest plant is in Jinja. It has an installed capacity of 1,900 million sticks per annum. The factory processed 1,507 tonnes of tobacco for cigarette production, and produced 1,602 million[318] sticks in 1999. The number of sticks produced in 2000 reduced to 1,344 million.[319] Tobacco export rose from 8.136 tonnes[320] in 1999 to 14,127 tonnes[321] in 2000. Although there is decrease in sticks produced, there was increase in the amount of tobacco exported. The amount of tobacco processed for cigarette production and specific energy consumption are shown in Appendix A Figure A6.9.

h) National Water and Sewage Corporation

The National Water and Sewage Corporation is a major utility and one of the leading electrical energy consumers in the country. It has ten branches located in the major towns in Uganda namely, Jinja, Entebbe, Lira, Gulu, Mbarara, Mbale, Kabale, Kasese Fort Portal, Lira, and Arua. The largest plants are located in Bugolobi and Gaba in Kampala. In the towns where supply of electricity is not reliable, diesel generators are used.

There are primary and secondary processes in the main plant at Gaba. The primary processes consist of raw water abstraction, clarification, filtration, chlorination, back-washing and high-pressure pumping. The secondary process basically involves sewage treatment. Energy is used mostly in pumping of water. The energy consuming equipment includes six high pressure pumps at the water treatment plant. Each pump is rated at 375 kW, 200 meter head with delivery capacity of 875 m^3 of water per hour. There are three low-pressure water pumps rated at 90 kW, 12 meter head and a delivery capacity of 1750 m^3 per hour. There are two back-wash pumps rated at 55 kW. The data available for the months of January 1997 to November 1999 are tabulated in Appendix B Table B6.15.
The specific energy consumption is increasing. Most of the equipment is old and the demand for water is increasing. There is no proper energy management in the institution.

Large electric motors start without appropriate relays. Despite the fact that the plant has a high-energy consumption, there is no energy manager. The National Water and Sewage Corporation should investigate the possibility of using methane generated from the sewage system for production of energy for process and water pumping.

6.7.4 Small-Scale Industries

Lime Production

Lime is used in road and building construction. The demand for lime has of recent increased due to the on-going road construction. There are many limestone quarries at Tororo, Kasese and Kisoro. There is high-quality lime from Karamoja region. In the traditional kilns, 800-1000 kg of wood is used per tonne of limestone fed. The lime yield is about 52%. The specific energy consumption is about 32 MJ/kg. The national annual demand for lime is about 200,000 tonnes. Some lime is imported mainly from Kenya and other countries. The national production is estimated at 100,000 tonnes per annum. The production of lime is made to order and is intermittent. With improved kilns, which work on a continuous process, 500-550 kg of firewood can be used per tonne of limestone charged. Specific energy consumption for lime production using an improved kiln is 16 MJ/kg. Estimated total energy consumption when using a traditional kiln is 3.18 PJ. It is possible to reduce energy consumption from the present value to 2.36 PJ by introduction of the improved kiln.[322] The differences between the two types of kiln are shown in Appendix B Table B6.16.

Jaggery

Jaggery is a relatively inferior form of sugar, which is somewhere between molasses and unrefined castor sugar. It is a 100% product of sugar with no additives. It is estimated that there are about 100 jaggeries countrywide. Those that are near the grid use electricity, while those located far from the grid use diesel generators to power cane crushers. A survey was made in 4 jaggeries in Uganda.

Most of the jaggery is used in local brewing. Initially the jaggery industry was dependent on firewood as the main source of fuel. When firewood became scarce and expensive, some people abandoned the trade. But of recent, they have begun using dried bagasse, to boil the juice as a supplement for firewood. Although there seems to have been revitalisation of the industry, the number of jaggery plants is on the decline.

The specific consumption of the jaggery was computed as shown in Appendix B Table B6.17. The main source of energy is biomass. There is limited use of electricity and diesel engines as a prime mover for cane crushers. The estimated production of jaggery was 16,537 tonnes per annum. The total energy consumption was estimated to be 0.587 PJ. However, there is poor storage of the bagasse. The boiling process is inefficient leading to excessive heat loss in the process. There is need to redesign the firebox to suit bagasse since it was originally designed for firewood.

Tobacco

The West Nile region produces about 80% of the tobacco grown in Uganda. In other areas like Rukingiri, Hoima and Gulu tobacco is also grown. The tobacco industry uses woodfuel for curing tobacco leaves. There are four types of barns used in the West Nile region, namely the traditional, *Malakisi*, Malawian and *Venturi*. These barns and their specific fuel consumption is shown Appendix B TableB6.18. Generally each barn has the capacity to cure about 300 kg of tobacco. Most of the barns have six tiers and can carry up to 298 bundles called "*fitos*".

Flue-cured tobacco is grown in most of these districts, except Hoima where sun or air-cured tobacco is grown. These varieties do not consume wood fuel apart from the poles for construction of curing barns, grading shades and similar structural supports.

Most of the farmers have been converting their barns to the *venturi* type. The curing process takes about one week. Tiles and galvanised iron sheet were used for construction of barns' roofs. Until recently most of the barns used grass thatched cover because it is not only cheap but it avoids sweating and eases the temperature control. The average acreage per family is 0.35. There are 18,417 tobacco farmers with about 20,000 barns in the West Nile region. The tobacco production in 1999 (base year) was about 16,460 tonnes.

In Rukungiri, similar work of converting from other types of kiln to the venturi kiln is taking place. There are about 4,000 barns in Rukingiri. The BAT is concerned about the impact of the industry on the environment and is encouraging farmers to grow trees in their gardens for curing tobacco. That would lessen the pressure from BAT to maintain plantations for wood supply. Due to the farmers' reluctance, the company has started its own plantation, with 200 hectare in 1999 and 500 hectare in each of the following four years.

There has been a remarkable decrease in the specific fuel consumption in the West Nile region. The trend for the last three years is illustrated in Appendix B Table B6.19.
Over the last decade, the specific energy consumption has decreased from 8 to 3.5 kg woodfuel/kg tobacco. It is estimated that 75% of the tobacco was cured using *Venturi,* while the rest uses *Malakisi V* barns. The average value of specific energy consumption was 4.87, implying that 77.92 MJ is used to cure one kilogram of tobacco in Uganda. In 1997, a specific energy consumption of 5.5 was given by the International Tobacco Growers' Association, based on 14 countries worldwide.[323] This equates to about 82.5 MJ of firewood being consumed per kilogram of flue-cured tobacco. It has been assumed that for the next three years and beyond, a specific fuel consumption of 52.5 MJ of fuel wood per kilogram of flue-cured tobacco is a reasonable estimate. The amount of flue-cured tobacco produced was 14.104 tonnes in 1999. Total biomass energy consumption was 1.076 PJ.

Small-scale brick making

Brick making is one of the flourishing small-scale industries in Uganda. It relies on firewood for firing bricks. There are few medium scale companies that produce bricks and tiles. A typical house in the rural areas needs between 4,000 and 6,000 bricks. It is estimated that 50 % of houses in the rural areas use bricks for construction and the rest use mud and wattle. In the traditional kilns, 105 GJ of biomass is needed to fire a batch of

9,000 bricks. The average data obtained from traditional kilns indicates a specific energy consumption of 2.34 MJ/kg. The traditional kiln is broken-up after use. There is scope to improve the efficiency of these kilns.

These kilns are similar to the Indian rural clamps with a specific energy consumption of 1.5-2.5 MJ/kg. It would be possible to reduce the specific fuel consumption to 1.1 to 1.5 MJ/kg by using Indian bull trench kilns.[324] By using the vertical shaft kiln, the specific energy consumption can be reduced to 0.75 - 1 MJ/kg of fired brick. [325] The total energy consumption in 1999 (base year) in this sector was 4.56 PJ.

Fishing
Lake Victoria is the leading source of fish supply in Uganda. About 226,090 metric tonnes of fish was harvested in 1999. Although Uganda has 41 per cent of Victoria Lake, Kenya with only 6 percent harvests more that 180,000 tonnes a year.[326] Fish export was 14,760 tonnes valued at US$ 31million in the year 2000. Fish exports are expected to increase because the European Union has lifted the ban on fish imports from Uganda. The major markets are the European Union, the Middle East and the Far East.

Fish smoking is one of the major economic activities on the Lake shores and landing sites on the islands. Traditionally, open fire smoking is common. It is estimated that 33,000 tonnes of fish are smoked annually. Due to the growing scarcity of firewood, a more efficient enclosed fire for smoking was introduced in Uganda, with a specific energy consumption of 0.5 kg wood per kilogram of fish. It is very slow to operate. The specific energy is about 1.5 kg of firewood per kilogram in open fish smoking. It is estimated that 9,900 tonnes of fish was closed-fire smoked while 23,100 tonnes was open-fire smoked. The total fuelwood consumption is 595 TJ.

At present there are nine fish processing plants in Uganda and it is most likely that more companies will obtain licenses to install fish processing plants. As a result there will be less fish left for smoking, except in Western Uganda, where there are no fish processing plants.

Tea Industries

Tea production has continued to improve in the last decade. Five tea factories were surveyed during the study. In general, tea processing consists of withering, rolling, crushing, fermentation, drying and packing. When fresh tea leaves are received they undergo the withering process to reduce moisture in the leaves. Tea factories use firewood exclusively in the tea withering, curing and drying process. There are twenty-eight tea factories in Uganda.

The production of green tea was estimated at 139,508 tonnes in the year 2000, compared to 136,271 tonnes [327] in 1999 (base year). That translated to about 30,282 tonnes of processed tea. Total energy consumption in the tea industry is 2.17 PJ of which, biomass energy use is estimated to be 1.88 PJ, while electrical energy consumption is 293.6 TJ.

In the tea production process, electric and thermal energy is required for movement of the equipment as well as drying the tea. Factories that are near to the grid use national grid electricity, with diesel generators as standby. The use of wood for drying varies with period of harvest. The five tea factories visited obtained their power supplies from UEB. Each of the factories had 250 kVA generators as stand-by power supply.

The factories, which were rehabilitated, show specific fuel consumption based on thermal energy, varying between 12 and 19 MJ/kg. The specific energy consumption based on electrical specific energy varies between 1.9 and 2.3 MJ/kg. In Sri Lanka, the thermal specific energy lies between 19 and 26 MJ/kg, the specific energy based on electrical energy varies between 1.73 MJ/kg and 2.2 MJ/kg.[328] There is similarity in specific energy consumption based on electrical energy in Uganda and Sri Lanka. However, the specific energy based on thermal energy is lower in Uganda than in Sri Lanka. The average specific energy consumption in Uganda tea processing is 15.93 MJ/kg as illustrated in Appendix B Table B6.20. In the Woody Biomass study, energy consumption in the tea industry in 1994 was estimated at 31,000 tones of wood. This is equivalent to 0.465 PJ, but in that study it was indicated that 210 TJ was consumed in tea industry. [329]

Cotton Ginnery

Cotton production is estimated at 100,000 bales per annum. There are 67 ginneries in Uganda. Most of the ginneries are located in the West Nile and Eastern regions. Those of the eastern region are grid-connected while the West Nile region relies on diesel generators to process the cotton. The largest ginnery in the region is the Parombo Ginnery. The plant has 30 gins, but they run at half capacity due to lack of adequate power to run all the machines. The main source of power is a 511 kVA generator and two stand-by 200 kVA diesel generators. Estimated fuel consumption is 36 litres per hour. The factory works in two shifts, producing 80 bales of cotton per day, that is about 10,000 bales a year, each bale weighing 185 kg. The specific energy consumption is 1.58 MJ/kg

The West Nile Co-operative Union (Cotton Ginnery) located in Pakwach produces 40 bales a day. They have two 288-kVA generators. The fuel consumption rate is about 25 litres per hour. The specific energy consumption is 2.2 MJ/kg. A small capacity ginnery has higher specific energy consumption than a larger one.

Coffee Processing

Coffee production has been on the decline due to fluctuations of world market prices, the occasional drought, and partly the wilt disease. There are about 440 coffee factories in Uganda. In the recent past, there were many diesel-powered coffee processing factories in Uganda. Most of them closed down due to the limited supply of coffee coupled with high prices of fuel, and the poor world market. The generators commonly used are 200-280 kVA capacity. Two of the factories visited in Kagadi, have a processing capacity of 6,000 tonnes per year. The fuel consumption was 39 litres per hour. The annual consumption was estimated to be 5,000 litres. But the equipment power requirement was about 90 kW. This implies that some factories had installed higher capacity generators than they required. This was because the generators were bought in bulk by the Coffee Development Authority. The Coffee Development Authority imported standard units and these were distributed to the coffee processors, without undertaking a thorough study of the individual needs and the capacity of the coffee processors.

In the highlands of the West Nile Region, where Arabica Coffee is a chief crop, there are four diesel generators within a radius of 4 km from Phaida town. They were forced to close the plants and transfer their generators elsewhere. They suffered the similar fate as other coffee processors in the rural areas.

6.7.5 Mining Sector

The Kasese Cobalt Company Ltd (KCCL) is the largest mining company in Uganda. It produced cobalt from ores left by the Kilembe Mine before it closed. The KCCL has an installed 10 MW hydropower plant for its own use but it is supplemented by the national grid. Kilembe Mines was the largest mining company in Uganda. It used to produce copper. It has a hydropower plant with a capacity of 5.5 MW. Most of the power is sold to the Uganda Electricity Transmission Company. There are few mines that have prospects of development in the foreseeable future. The Busitema Mining Company deals in gold mining. They have a plan to increase the mining from 7,000 tonnes to 50,000 tonnes of rock per day. At present they are supplied by the national grid and diesel generators. They are planning to install a gold processing plant in the future.

The largest vermiculite mine in Uganda is located at Namakala in Mbale District. Camin Resource capacity at present is 20,000 tonnes of rock per day. The plant has an installed capacity of 100,000 tonnes of rock per day. The limitation is the limited availability of power. Vermiculite finds application in refractory material. Unprocessed vermiculite is exported.

Wolfram is mined at Kirwa in Kisoro. It had its own micro hydro plant. However, the company has suffered, due to high operational costs and a lack of power. The firm used to import power from Rwanda. There is plan to revive the operation of wolfram mining.

High-grade iron ore deposits are found in Muko, Kabale District. It is estimated that 45 percent of the ore is iron and it has a low phosphorous content. There is no infrastructure suitable for mining. The estimated deposit is over 5 million tonnes. At present most the steel industry in Uganda relies on local scrap materials and ingots from Southern Africa.

6.8 Commercial Sector

The main sources of energy in the commercial sector are fuel-wood, charcoal and electricity. Biomass energy is mostly used in restaurants, hotels, local brewery, distilleries and bakeries. These institutions use energy for cooking, lighting and baking. This sector mostly relies on electricity for lighting and biomass for cooking. But of recent there has been an increasing trend in the use of LPG for cooking and water heating in the commercial sector and higher institutions of learning. Most of these institutions are located in the central region.

Biomass is the leading energy provider in the commercial sector. The use of electricity is about 385.3 TJ.[330] The use of LPG is limited to Universities, restaurants, hotels and some boarding schools. Traditional brewing and distilling is the largest user of biomass.

In the 1999 (base year) the national energy balance was estimated at 11 TJ of LPG. This was used in the industrial sector. This is not justifiable. In this study the use of LPG is limited to domestic and commercial sectors. The commercial sector's consumption of LPG was 74.1 TJ. The estimated total energy consumption in the commercial sector was 21.4 PJ. In the national energy balance, use of charcoal in households and the commercial sector was combined. In this study, the distribution of energy in commercial sectors is as shown in Figure 6.13.

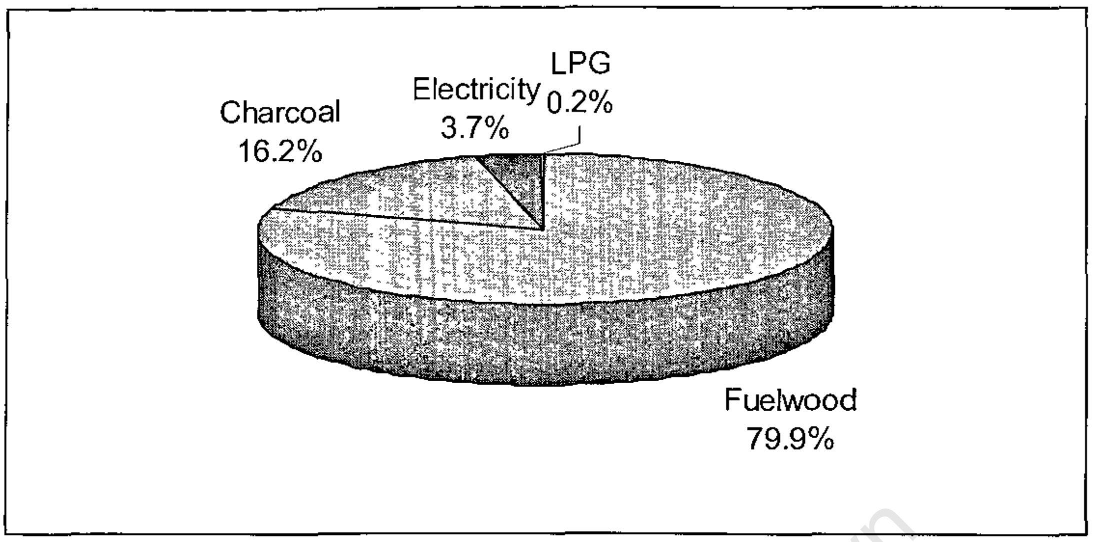

Figure 6.13 : Energy mix in the commercial sector

Estimated energy use is less than the data given in the energy balance and data from the Forestry Department. In both cases, no recent studies have been made. The last studies were done in 1994.

6.8.1 Hotels and Restaurants

With the exception of a few four-star and five-star hotels, most of the hotels and restaurants rely on biomass for cooking. Kampala Sheraton is the biggest hotel in Uganda and one of the leading electricity consumers with an annual electric consumption of 7.8 TJ. The hotels that rely on biomass are classified into two categories depending on the number of employees. Those that employ more than 5 workers and the small ones; employing less than 5 workers. In the small hotels and restaurants category, lodges and eating-houses are included. From a survey carried out in Kampala, large hotels use about 821 GJ of energy from charcoal and 164 GJ from firewood per annum. On the other hand, small hotels and restaurants use 60 percent charcoal and 40 percent firewood. They use 150 GJ from firewood and 90 GJ from charcoal per annum. The total energy use in hotels and restaurants for cooking is 6.98 PJ of which charcoal contributes 3.62 PJ while firewood contributes the rest.

6.8.2 Bakeries

There are about 57 bakeries using biomass located in different towns all over the country. Those bakeries in the major towns use electricity for baking. However there are small bakeries that rely on biomass in urban areas. Most of the bakeries outside Kampala depend on firewood because of the low operation costs and reliability. Most of the bakeries are located in the city, municipalities and town councils. A survey was conducted in five bakeries using firewood only. The estimated specific energy consumption based on biomass is 15 MJ per kilogram of loaf. These bakeries produce bread is estimated to be 195,770 loaves a day. The annual biomass energy consumption is 440 TJ. There is a limited and unreliable electricity supply in most of the upcountry towns. The bakeries that rely on biomass will increase in number because of the recent increase in electricity tariffs.

6.8.3 Breweries and Distilleries

Brewing businesses are very popular in the low-income urban areas. They are mainly located in the slums. Women operate most of the local brewing businesses. The raw materials used for local brew production are largely from carbohydrates. The most common raw materials are millet, banana and sorghum. They rely on firewood for boiling the brew. It is estimated that there are 17,139 local breweries and distillers in urban slums and 172,518 in the rural areas. It is a popular social meeting place in both urban and rural areas. Surveys were made in four distilleries in urban areas and three distilleries in the rural areas. The distilleries use similar methods of distilling irrespective of their location. The estimated biomass energy use per distillery is 45 GJ and 67.5 GJ for rural and urban areas respectively. Total energy consumption is 8.92 PJ.

6.9 Institutions

Institutions like schools, hospitals and prisons consume appreciable amounts of biomass energy. The greatest increase in the near future will be biomass consumption in schools. There is potential for energy savings in this sector.

Hospitals

Uganda has 104 hospitals with 25,628 beds [331] of which 57 are run by the government, 44 are run by non-governmental organisations and they are private. There are 250 health centres country wide. There has not been a significant increase in the number of the patients in hospitals. Most hospitals use three-stone stoves and charcoal stoves for cooking. The use of LPG is negligible. As fuel wood get scarce, the use of LPG will be increased in the future.

Most of the hospitals depend on biomass for cooking. Firewood is the most popular source of energy used for cooking. The use of improved stoves is very limited in government hospitals. In most cases, visitors are allowed to bring cooked food to patients. A survey was conducted in four hospitals in Uganda. Fuelwood consumption is estimated to be 24.3 MJ per person per day. In 1999, total biomass energy consumption in hospitals was 251.76 TJ.

Electricity is used for running equipment and autoclaves. The use of solar energy is common in the remote missionary hospitals. The solar energy is used mostly for lighting and at times in refrigerators. However in some cases it is used for computer power supply. There are a few hospitals that run on generators, but in most cases the generators are idle. Most of the generators are of capacity 100-125 kVA. The fuel consumption is estimated to be 25 to 30 litres per hour. The grant given to the districts' hospitals is too little to sustain the use of generators. Some hospitals have reverted to using 40 kVA generators to power basic equipment like x-rays and other equipment used in the theatres. The fuel consumption for a 40-kVA generator is estimated to be between 10 and 15 litres per hour depending on the make and condition of service.

Prisons

There are 48 prisons in Uganda. The number of prisoners has almost doubled over the last four years from 8,746 to 15,913. [332] The prisons rely on firewood for cooking. They generally use three stone stoves, which are very inefficient and generate a lot of smoke.

The estimated energy consumption of biomass per prisoner per day was 25.5 MJ. The estimated total biomass energy consumption is 148.11 TJ.

Schools

As the result of government policy of Universal Primary Education, there has been a high increase in the primary school enrolment from 2.63 million pupils in 1995 to 6.59 million pupils in 1999. At the same time the enrolment in secondary schools increased from 255,048 to 458,263 students.[334] The student enrolment and percentage increase for primary and secondary schools are shown in Appendix B Table B6.21 and Table B6.22. There are fewer boarding schools than day schools as shown in Appendix A Table B6.23. Most of schools use firewood for cooking. In this study, 10 boarding schools and 30`day schools were surveyed.

Data from boarding schools was collected for a period of three years (1997-1999). The average yearly data is given in Appendix B Table B6.24. There were few schools that have started using LPG for cooking to supplement firewood. It is estimated that 15 percent of primary day schools and 30 percent of secondary day schools provide lunch to students. The biomass energy consumption per student in a boarding school is 4.04 GJ and 4.39 GJ per annum for primary and secondary schools respectively. A school with boarding and day students, the biomass energy consumption is 2.10 GJ and 2.44 GJ per annum for primary and secondary schools respectively. In the day schools per capita biomass energy consumption for primary and secondary schools was 1.39 GJ and 1.59 PJ respectively. The total amount of biomass energy consumption in both primary and secondary schools is given in Appendix B Table B6.25. In 1999, the total biomass energy consumption in primary and secondary schools was 2.60 PJ.

University Halls of Residence

Biomass has been the leading source of energy for cooking in the Makerere University Halls of residence over the last decade. Since the academic year 1997/98, there was a shift towards the use of LPG in the University. In this study, the average data for the academic year 1995/96 to 1998/99 was analysed. The data is presented in Appendix B

Table B6.26. Electricity is used for lighting and water heating. The percentages of energy use in Makerere University Halls of residence are as shown in Figure 6.14.

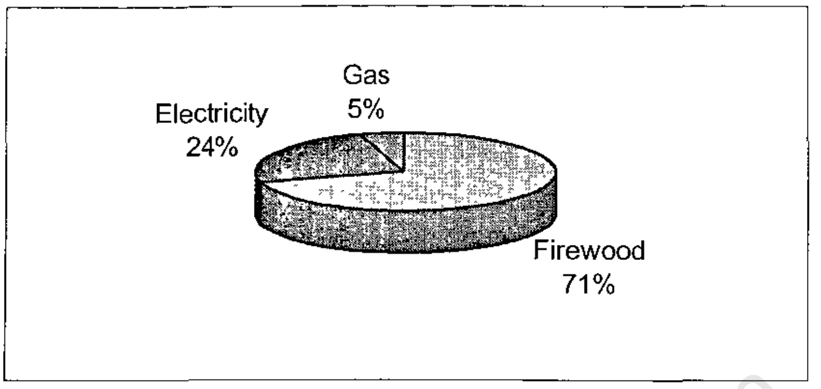

Figure 6.14: Energy use in the halls of residence in Makerere University

In spite of being cheap, the use of firewood has been decreasing as the University opted to use cleaner sources of energy for cooking. The installations of LPG appliances in all halls of residence and storage were in progress. The LPG is imported as opposed to firewood. Energy consumption in Makerere University was 22.6 MJ per student per day. Estimated energy consumption in Makerere University Halls of residence was 38.74 TJ per annum.

Other institutions of higher learning have more than 59,900 students. Their energy consumption was 383.68 TJ. The total annual energy consumption in the institutions of higher learning was 422.42 TJ of which biomass constitutes 383.32 TJ. The summary of energy consumption in the commercial sector is as shown in Appendix B Table B6.27. In 1999, the total biomass consumption is 19.87 PJ.

Fuelwood supply

The Towns and cities are expanding; land outside large towns is normally better used for agricultural purposes than planting trees. The government needs land for purposes other than fuelwood supply. As an example the peri-urban plantation in Namanve, which was supposed to be source of fuelwood for Kampala City, was converted to industrial park. The landscape is changing with increasing development. Land is getting scarcer and value is appreciating annually. It is very important to plan for such areas to provide biomass energy far well in advance and not too close to the cities.

6.10 Transport Sector

Transport sector issues in Uganda are pertinent to a number of ministries and institutions. The Ministry of Works, Housing and Communication (MOWHC) is the key Ministry responsible for the general policy framework for the transport sector in Uganda. The Ministry of Energy and Mineral Development is responsible for energy provision and utilisation policy, while the Ministry of Finance, Planning and Economic Development is responsible for the taxation policy aspects of the sector.

The MOWHC managed 9,700 km of the roads prior to 1998. This represents 10% of the total road network. In 1998, 24,000 km of the Ministry of Local Government's road network was transferred to Ministry of Works Housing and Communication to facilitate maintenance.

Road, rail, marine and air constitute the principal modes of transport in Uganda. The railway network is very poor and inadequate. Uganda therefore relies on road transport for both goods and people. Mini-buses and taxicabs dominate passenger transport while pick-ups and lorries dominate goods transport. Buses are more prominent on long distance routes for upcountry destinations. The transport sector is the leading consumer of petroleum products. The total Petrol consumption decreased from 14.80 PJ in 1999 to 14.66 PJ in 2000. Diesel consumption increased from 5.98 PJ to 6.43 PJ over the same period. This is due to lower pump price for diesel than petrol. In the national energy balance, the energy consumption in transport was estimated at 13.72 PJ and 13.16 PJ for 1999 and 2000 respectively. [334]

In this study energy consumption in the transport sector in 1999 (base year) was estimated at 15.4 PJ. The difference between the estimates for 1999 could be attributed to the fuel smuggled into the country.

The transport sector is one of the leading contributors to the tax revenue in Uganda. The taxes on fuel are the highest in the region; consequently this made pump prices higher in Uganda than Rwanda in 1999. In the year 1999/2000 the contribution of taxes on petroleum products to the total revenue was 19.2 per cent [335]. There have been increases in the pump prices in the region in 2000. The regional pump prices are as shown in Appendix B Table B6.28. Freight and insurance costs amount to about 40 percent of CIF landed cost thereby highlighting the need for cheaper transportation modes such as pipelines and rail ferry wagons.

The road transport fleet in Uganda in 1999 was estimated at 186,244 and has been growing steadily at a rate of over 20 percent per annum in the last decade. The number of motor vehicles is 6 per 1000 people in Uganda. This is still very low when compared with other countries. This is shown in Appendix B Table B6.30. Although the number of people per vehicle is low, the growth rate is above the national urban population growth rates over the decade.

Most of the imported vehicles are used or reconditioned. The main source of the vehicles is Japan and via the Middle East. There has been an increase in the number of vehicles over the last decade. This is illustrated in Figure 6.15.

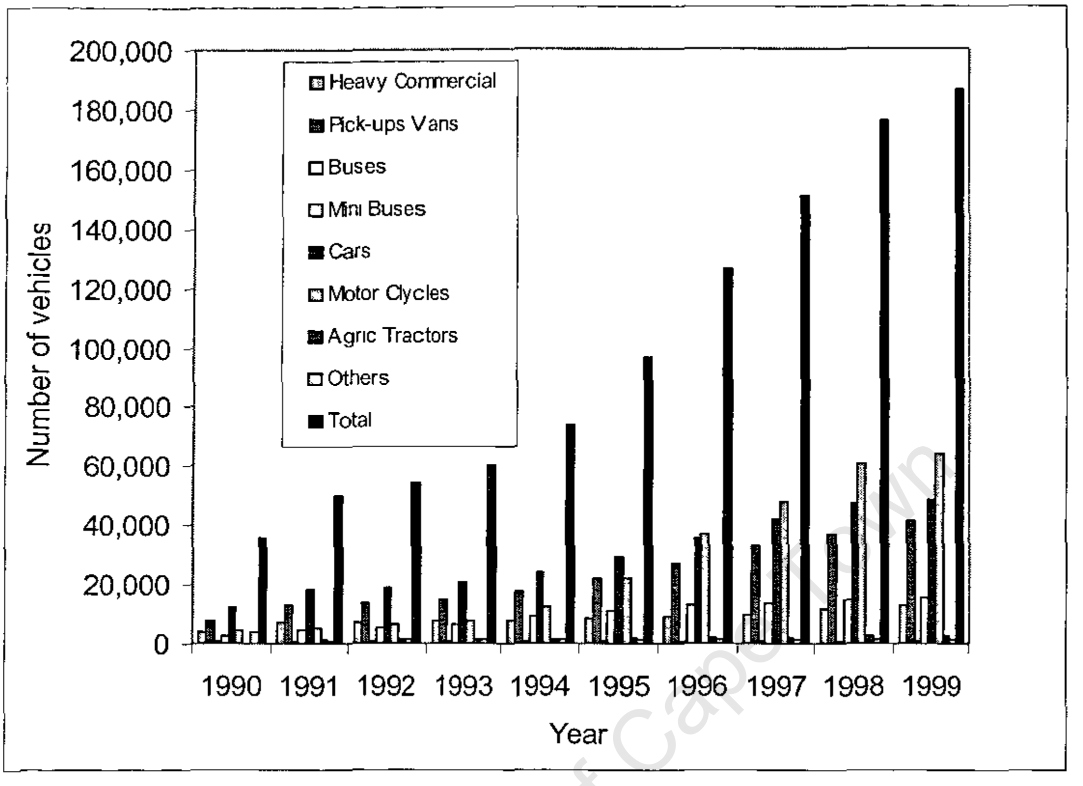

Figure 6.15: Estimated number of vehicles on the road (1990-1999)

The number of vehicles in 2000 was 189,105, representing an increase of only 2 per cent from 1999. The highest increment was 31 per cent, recorded in 1996. The general declining trend over the last five years is as shown in Figure 6.16.

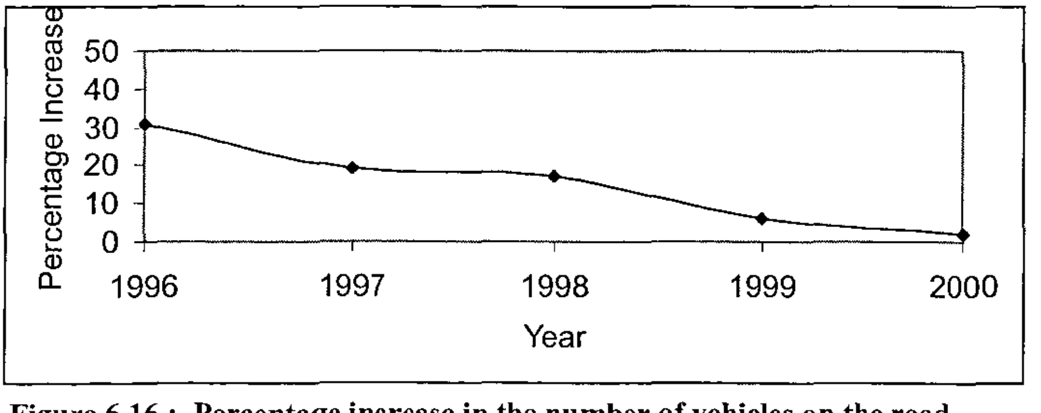

Figure 6.16 : Percentage increase in the number of vehicles on the road

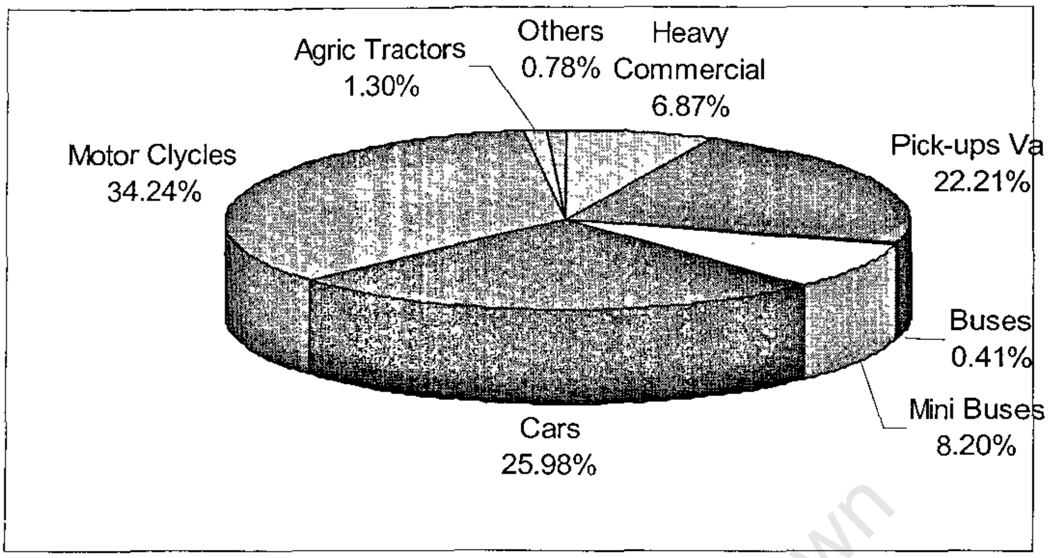

Figure 6.17: The distribution of transport vehicles by type in 1999

Motor cycles dominate the transport sector especially for short distance travel. As can be seen in Figure 6.17 it has the highest rate of increase over the last decade. Private cars constitute about 26% of the total vehicles on the road. The variations in pump prices of petroleum products over the last decade are illustrated in Figure 6.18.

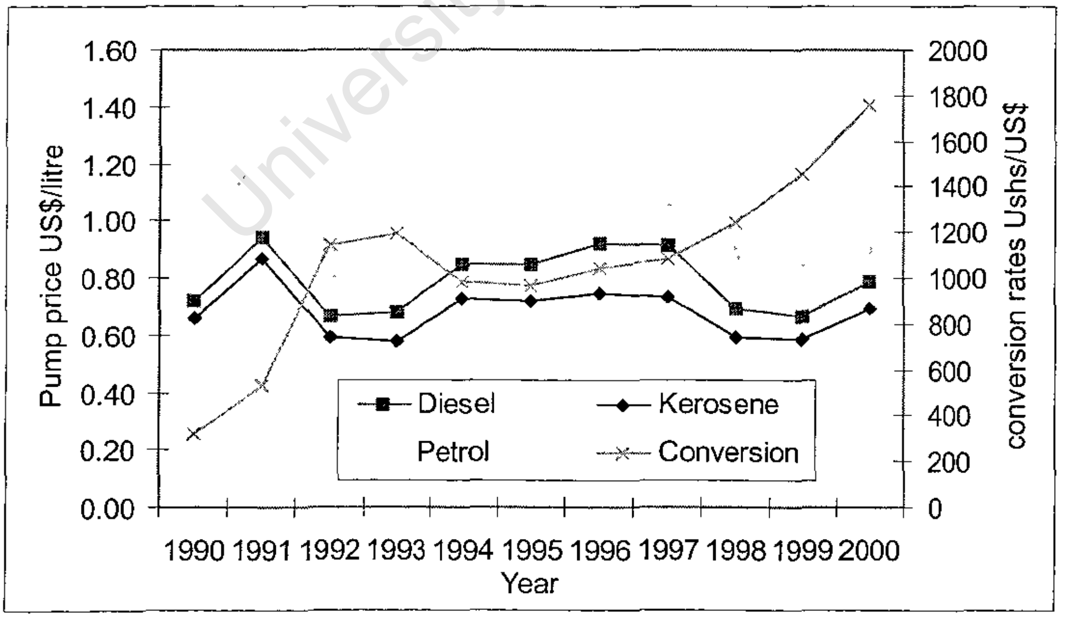

Fig. 6.18 : Variations in pump prices of petroleum products (1990-2000)

Although there were increases in the number of vehicles, the largest increase was over 35 per cent per annum for motor cycles. It is the fastest growing mode of transport in both the urban and rural areas, while minibus growth rate is about 16 percent per annum as shown in Figure 6.19. Motor cycles will not have a major impact in commercial energy consumption because of their low energy consumption rates.

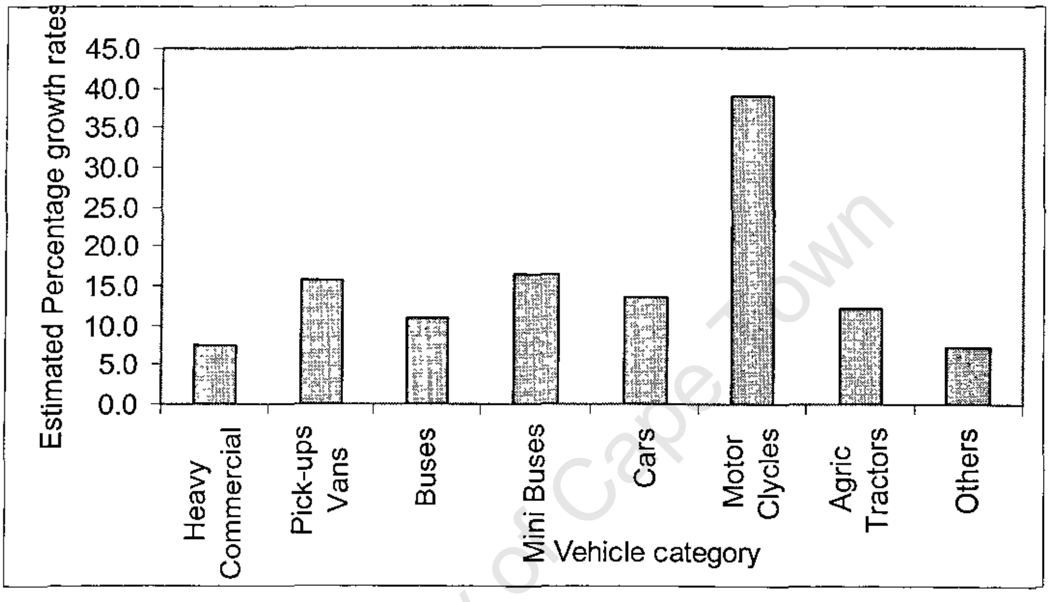

Fig 6.19: Average increase in the number of different types of vehicles (1990-1999)

The transport sector contribution to GDP was Ushs.429.8 billion of the total Ush.9, 683.9 billion. The road transport is one of the sectors that contribute to the GDP. The growth rate of this sectors' contribution to GDP decreased from 6.6 % in 1999 to 3.4 % in 2000, but in the 2001, a growth of 8.2 % [336] was realised. The trend is most likely to continue but at lower rates.

It is interesting to note that the number of petroleum retail outlets have been increasing over the last three years. The new entrants to the petroleum sector constructed most of the new outlets. The major oil companies were also engaged in limited construction of outlets. One of the reasons could be that there was limited foreign exchange for expatriation to the multinational companies.

There have been corresponding increases in fuel consumption over the decade. But in 2000, there was a decrease in the gasoline consumption that could have either been due to smuggling or an increase in diesel minibuses because of the high petrol prices. There was an increase in the diesel consumption due to the lower cost of diesel and increased number of diesel vehicles. It is estimated that 80% of diesel is used in the transport sector while diesel generators countrywide use 20 % of the total imported diesel. In 1999 it was estimated that 20 % of the diesel was used to run generators due to inadequate electric power supply from hydro power stations. The situation was improved when 80 MW more was generated from the Kiira Hydropower Station to increase the power supply from 180 MW to 260 MW in 2000.

6.10.1 Energy use in Transport Sector

Road transport will continue to be the dominant mode of the transport for both passenger and freight. The minibus is main mean of transport in urban area and towns, which are less than 200 kilometres from Kampala. It estimated that 60 % of all the vehicle fleet operates within the capital city, Kampala. [337] The distribution of the modes of transport for passengers is as shown in Figure. 6.21. The total number of passenger – kilometres is 1.9 billion. The details are contained in Appendix B Table B6.30. The passenger energy intensity per is illustrated in the Appendix B Table B6.31.

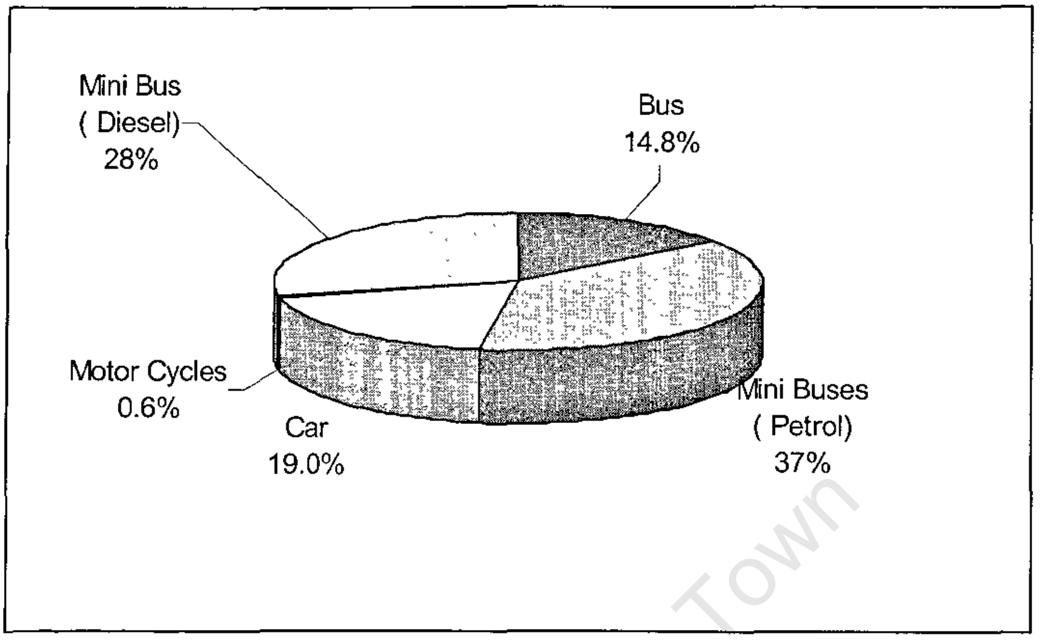

Figure 6.20: Modes of transport for passengers

6.10.1.1 Passenger Transport

Buses are the most popular means of transport for long distance travel. The numbers of buses have been increasing at a rate of 10 per cent per annum over the last decade. The town services are monopolised by minibuses buses contribute less than 15 % of total number of passengers. The competition for passengers is too stiff for the would-be bus operators. In 1999, it was estimated that there were about 770 buses on the road in Uganda.[338] Estimated energy consumption by buses was 414 TJ.

6.10.1.2 Freight Transport

Heavy commercial vehicles and pick-ups are the categories of vehicle used in freight transport. The use of locomotives is very limited. The per capita tonne-kilometre in 1999 was 301. Rail system contribution to the freight transport is less than 3% of the total tonne-kilometres. The total energy consumption in freight transport was 5.9 PJ.

The details of vehicle categories and tonne-kilometres for the road freight transport and the energy intensity is as illustrated in Appendix B Table B6.33 and Table B6.34 respectively.

6.10.1.3 Rail Transport Services

Uganda Railway Corporation is a Government parasitical under the Ministry of Works, Transport and Housing, responsible for operating and managing of railway and marine services in Uganda. It has got a railway line system of 1300 kilometres, out of which only 290 kilometres are operational. There are 997 kilometres of railway lines that were suspended either for being uneconomical or insecure. The active marine service covers 1673 kilometres, linking the ports in Kenya and Tanzania. [339] The Ugandan Railways comprises of 1,250 kilometres of track. Less than 10 per cent of the domestic and less than 30 per cent of external trade freight is carried by rail. The rail services largely depend on the capacity and volume of imports and exports. There has been a decrease in traffic due to decreasing imports.

There is expected to be an increase in goods traffic due to the enforcement of the axle load limits resulting in excess freight being shifted to rail transport. All the locomotives are diesel powered. The marine services are operating between Jinja and Portbell in Uganda, Mwanza in Tanzania and Kisumu in Kenya. Since 1997, the Uganda Railways Corporation has not been operating passenger services. The estimated goods traffic increased from 199,494 thousand tonne kilometres in 1999 to 209,534 thousand tonne kilometres in 2000. [340] However, there is the possibility of reviving the sector that can be done by privatising the company.

In April 2000, the government decided to privatise Uganda Railways Corporation via a long-term concession. The government is in process of carrying out a review of Uganda Railway sector, to determine the necessary legislative, institutional and regulatory reforms required to facilitate the introduction of the private sector in the railways industry. [341] Under the plan suggested by the consultant, URC will be spilt into two: the operational arm to be a concession to the private sector and an assets holding company that will be in charge of government property. A regulator will also be set up in the Ministry of Works, Housing and Communication and legislative amendments made for private sector participation. [342] The number of tonne – kilometres and fuel consumption by locomotives is illustrated in Appendix B Table B6.35.

6.10.1.4 Air Transport

Air transport and support services have not expanded significantly. The growth rate is about 1% per annum. Currently, 14 international airlines operate in Uganda. The only state-owned commercial air Transport Company, the Uganda Airlines Corporation, is under liquidation. This is also reflected in the importation of aviation fuel and power kerosene. The total fuel consumption in the sector has decreased from 2.22 PJ in 1999 to 1.90 PJ in 2000. The aviation fuel reduced from 0.45 PJ in 1999 to 0.43 in 2000.[343] In 1999 (base year) the number of passengers was 449,000 that represents about 0.002 (passenger /per population), which is very small. The political and economic stability in the Great Lakes Region has a great effect in this sector. The present political instability has lead to reduction of tourist and business travel to this region.

6.11 Electricity Discussions

Electric energy is the main driving force in the manufacturing sector. There have been delays in the construction of Bujagali hydropower plant. In the first place, it took the government a long time to classify Karuma as a first track project. The government argument was that if the two power stations were commissioned simultaneously, the countries in the region would not be able to utilise all the power generated. Secondly, the power purchase agreement demands that all power produced must be paid for. The initial project developers abandoned the site. However, there are other firms that have shown interest.

Furthermore apart from the long drought, there is the possibility that more water will be withdrawn from Lake Victoria when Kiira hydropower is completed. Only three out of the four turbines have so far been installed. Further, financing large scale power systems in country like Uganda is not easy due to political uncertainty.

Prior to unbundling the Uganda Electricity Board, there was a standard national tariff for different consumer sectors. But when the Electricity Act came into effect, the private sector started to invest in power generation. In areas like Arua, West Nile a thermal plant with a capacity of 1.4 MW was installed to provide power to Arua and Nebbi towns. The

Electricity Act requires consumers to pay the marginal cost of power generation, thus to pay more for thermal generation than hydro-based electricity. It is most likely that the tariffs will be revised upwards at the end of this year or even earlier. It is also possible however that one is likely to expect more defaulters and theft of electricity as the tariff is revised upwards. The nest chapter, Chapter seven will deal with energy projection

CHAPTER SEVEN
ENERGY PROJECTIONS

7.0 Introduction

Energy demand and supply projections are very important for the purpose of planning for energy needs of future. There are various models used in energy projections. In this study Long-range Energy Alternatives Planning system (LEAP); a scenario-based environment-modelling tool was used for analysis of energy projection. The energy consuming economy was divided into sectors, sub-sector, end use, and device and energy intensity. The major sectors are households, industries, commercial and the transport sector. The base year chosen for the study was 1999. The projected energy demand is for 2025. The estimated energy demand provides useful input to the national vision 2025.[344] The national vision was a study made by the Ministry Finance, Planning and Economic Development. The study demonstrated economic projection for 2025 basing on different scenarios, but the energy component was not considered. The results obtained in this research were compared with the previous estimates and appropriate comments were made.

7.1 Energy Demand Projection

In order to make a through analysis, several critical factors pertinent to energy demand and supply were taken into consideration. These factors include liberalisation of the economy, macroeconomic stability, foreign investments, regional co-operation and infrastructure development, investment climate and opportunities, policy, regional stability, poverty alleviation, corruption and the political environment. Those factors were considered when building scenarios. It was assumed that there is a linear relationship between energy demand and the parameters used for analysis. The data is used in energy projections using LEAP software.

7.1.1 Energy Demand Forecast Procedure

There are several models used in energy forecast. The model selected normally depends on the availability of the data and complexity based on the number of variables and parameters involved. Whichever model is chosen in the forecasting methods, there are fundamental steps that have to be taken, and these include: [345]

- collecting historical data of a period of time and adjust them to achieve a rational consistency,
- determining the effect of economy, demography, politics and geographical and any other factors that influenced energy demand in the past,
- extrapolating these factors into the future and determine the degree of uncertainty in each extrapolation,
- deriving the forecast by considering the effect extrapolated factors are expected to have during the time period chosen and
- periodically comparing the performance with previous forecasts and making appropriate adjustments in technique and assumptions.

7.1.2 Models Applied in Uganda

Energy planning tools are very important for decision making in energy planning. In 1983 and 1994 the UNDP/World Bank/ESMAP made a detailed energy analysis for Uganda. The study covered virtually all sectors of energy. In the study a commercial model was used to compute the energy-forecast. [346] The projected energy demand elasticities are as shown in Appendix B Table B7.1. After using the software, there was neither trace of the assumptions made nor human resource trained in the application of the software. The forecast was made up to the year 2012.

In 1998, PVDE Version 3.0 (electricity sales forecast), a software model, was used to forecast electricity demand in the medium and long term. It proposes a range of parameters, from analytical to econometric features, used in forecast techniques that can be adapted in a specific way to user's data. PVDE 3.0 can be used in extremely different contexts, among others; it deals with the case of developing countries. Its results can also be used to supply a load curve forecast model. [347]

Electric energy consumption in households was estimated based on a survey carried out in Kampala. In the study, electric energy consumption was estimated basing on the electrical equipment in the households.

The power consumption in industries, commercial and general sectors was projected using elasticities of the sector-wide power consumption, using the relevant variables. The selected explanatory variables and elasticity of sales to the explanatory variable electricity for different sectors are as shown in Appendix B Table B7.2 and Table B7.3. The Ministry of Energy and Mineral Development is planning to use:

- Model for Analysis of Energy Demand (MEAD)
- Energy Information System (ENIS)

The Ministry has gathered preliminary data for running the models. The MAED users should be in position to apply the model for long term energy demand forecast in the future. ENIS is a planning tool that can be used by the public administrators, energy industry or an information system for public access. [348] At present there is no collaboration between the Ministry of Energy and Mineral Development and Makerere University neither in the application nor training in the use of energy planning software.

The use of different commercial software in forecasting energy demand based on different scenarios is a common practice. In this study the variable parameters considered are GDP and population growth rates. The contributions of different sectors to the GDP were used as the major driving parameter in energy demand. The results were compared with the earlier studies.

7.1.3 Theory

The projection method determines how future energy intensities are calculated. Assumptions are based on specified targets for growth, use of micro-economic projections, projections developed by other analysts or in-depth analysis for particular parameters. The projected values used in this model were derived by interpolation, growth rates, drivers and elasticities.

Energy planning can not be dissociated from economic development. Therefore an attempt has been made by to establish a link between the evolution of national income Y and evolution of national energy demand X through 'demand elasticity'. Elasticity can be defined as follows: If there are active variables $y = f(x)$ and $x_i = (x_1, \ldots\ldots, x_n)$ then

$$\alpha = \frac{\Delta y_i / y_i}{\Delta x_i / x_i} = \frac{d \ln \ y}{d \ln \ x}$$

Computation of Energy Consumption

Energy consumption in households sector was computed from:

$$E_{total} = \sum_i A * \sum_i B * \sum_i C * \sum_i energy\,intensity$$

A : The percentage of household in a given category

B : Activities

C: The ratio of activities

Transport Sector

Where A = Transport mode

B = Load factor (passenger- kilometre / vehicle – kilometre)

$C = A * B = TotalTransportModePass - kilometre$

Calculating Energy Intensity

D= 1/(E*F) Energy intensity (litres/passenger-kilometre)

Where E= Transport mode fuel economy (vehicle –kilometre/litre)

F= Load factor (passenger-kilometre/vehicle kilometre)

Using the growth rate method, future activity levels would increase from the base year at an estimated annual growth rate. The drivers and elasticities were used to project energy intensity as a function of one or more driver variables with or without accompanying elasticities. This method assumes a standard log-log relationship between activities and the driver variables.

Growth Rates:

$FUTUREVAL_t = BASEYEARVAL*(1+GR)^t$

Where:

$FUTUREVAL$ = energy intensity in Base Year

GR = growth rate, $t = 0$ in the base year.

Projected activities with Log-Log Functions

The general form of the Log-Log (constant elasticity) function is as follows:

$$\frac{A_t}{A_0} = \left|\frac{D1_t}{D1_0}\right|^{\alpha 1} \cdot \left|\frac{D2_t}{D2_0}\right|^{\alpha 2} \cdot \left|\frac{D3_t}{D3_0}\right|^{\alpha 3}$$

Where :

A_0 is the base year energy intensity

A_t is its value in future year t

Dn_0 is the base year value of the driver variable n (n = 1, 2,3)

Dn_t is its value in future year t

α_n is the elasticity .

Equation 1 can also be expressed as follows:

$$LogA_t = k + \alpha 1.LogD1_t + \alpha 2.LogD2_t + \alpha 3.LogD3_t$$

Where:

Log is the natural logarithm function

k is a constant

The parameter A_0 can take different values depending on the factors under consideration. Among the factors it can take are population growth rate and GDP. Owing to lack of reliable elasticities, price relationships have not been considered separately in the study. As an example, if the price of fuel is increased the demand is expected to decrease. Since the price of fuel is high in Uganda, the effect of price increase is likely not make a significant reduction in demand. The demand for fuel growth rate is higher than GDP growth rate. Since the fuel consumption increase as the GDP improves, an over all elasticity was assumed to cater for price and GDP growth rate.

7.2 Factors Affecting Energy Demand

There are many factors that affect the future energy demand of a country. The most common factors are discussed in this section were the most crucial factors, used to build demand energy scenarios.

7.2.1 The Economy

Uganda is one of the least developed countries in the world. Uganda is still a poor country and this may not change in the near future. The government has initiated pro-business policies and relative stability has been achieved over the last decade. In the years 1990-2001, the GDP growth rate was 6.8 per cent per annum as opposed to 2 % and 3 % for Kenya and Tanzania respectively. [349] This robust expansion compares favourably with Sub-Saharan Africa's average growth rate of 2.6 per cent in the year 2001.[350] The level of growth seems high. That is due to the long stagnation period of the economy compared with stable countries like Kenya and Tanzania. GDP per capita was only US$320 in 1999, compared with US$ 360 for Kenya and US$ 240 for United Republic of Tanzania. In 1999, Uganda was ranked 190 out of 206 countries in terms of GDP per capita.[351] Real GDP in Uganda has been growing steadily over the past decade, recording an average of 6 per cent in the past five years compared to 2.3 per cent for Africa. The GDP per capita in 2002 was US$ 236 compared with US$ 393 for Kenya and US$ 267 for United Republic of Tanzania. [352]

Although Uganda has had impressive GDP growth rate over the last decade, for the last five years GDP decreased from 7.3 per cent to 4.9 per cent while GDP per capita has decreased from 3.8 per cent to 1.4 per cent. [353] The trend could partly be attributed to petroleum imports. The import bill for petroleum in 1999 (base year) was US$121.7 million, while import of all merchandise was US$1,363 million. In the year 2002, petroleum import bill was US$ 160 million, which was about 20 % of the total merchandise exports. [354]

Per capita energy consumption is sometimes used as a measure of national development. Per capita electricity consumption for Uganda was 52.3 kWh in 2000, which is very low when compared with Kenya and Tanzania with 142 kWh and 70.35 kWh respectively.[355] There is need for more power supply to facilitate national development. The need has not been met and as the result there is resumption of load shedding early this year.

7.2.2 Agriculture

Agriculture plays the leading role in Uganda's economy. It has the highest contribution to the GDP in terms of monetary and non-monetary GDP. Uganda relies largely on agriculture for export. The major cash crops in Uganda are coffee, cotton, tea and tobacco. Coffee, the leading export crop in Uganda, is exported in bean form. Uganda coffee production is about 3 per cent of the world production. It faces stiff competitions from Vietnam and Indonesia. Over 90 percent of cotton exports are in lint form. Despite the increase in the volume of exports, the expected foreign exchange is decreasing considerably due to the fall of the world market prices. Over the last five years, the exports of horticulture and processed fish have been increasing steadily.

The Agricultural sector contribution to GDP is 32 per cent monetary and 19 per cent non-monetary. The export of coffee for the year 1999 was 230,466 tonnes, valued at US$ 284.96 million, which was about 58.9 per cent of the total exports. [356] Uganda's coffee exports have fallen by US$194 million over the last two years. There is a need to increase agro-processing industries to add value to agricultural produce and so obtain better international market prices. Most of the agro-processing industries are not energy intensive.

The agriculture practice is largely manual, with an average of one tractor per 1000 agricultural workers. [357] There is a need to mechanise agriculture if production is to increase from subsistence to commercial farming. The increase in agriculture value added over the last decade was 3.8 percent per annum, while for Kenya and Tanzania it was 1.2 % and 3.3 % respectively. The average annual growth rate for agriculture value added in Sub-Saharan Africa was 2.8 percent. [358]

The Plan for Modernisation of Agriculture (PMA)[359] represents a comprehensive institutional policy and operational framework for poverty eradication by transforming agriculture from subsistence farming to a more commercially oriented enterprise. Energy demand in this sector would only increase if there was a significant increase in agriculture production.

7.2.3 Industry and Manufacturing

Uganda has great potential for industrial development in agro-processing and labour intensive industries. In order to facilitate industrial growth, there is a need to have a reliable supply of raw materials, continuous improvement in quality of products, increased worker productivity and reduction in transaction costs. Manufacturing is dominated by food processing, textiles and construction materials, which are becoming more efficient, partly due to import liberalisation. The production indices of some of these products have been decreasing because of importation of low quality products and flooding of goods in Uganda. These have led to declining industrial growth in the last three years.

Between 1990 and 2001, the average annual growth rates of value added industry was 11.9 per cent which is higher than that of Kenya and Tanzania with 1.6 per cent and 3.6 per cent respectively. The value compares very favourably with Sub-Saharan Africa's value of 1.7 per cent.[360]

Between 1990 and 2001, the average annual growth rates of value added manufacturing was 12.2 per cent which is higher than Kenya and Tanzania with 2 per cent and 3 per cent respectively. Although at present Kenya's economy is not performing well, it has the best industrial infrastructure in the region. These values compare poorly with Sub-Saharan Africa's value added of 16 per cent.[361] The manufacturing value added contribution to GDP sector's contribution to GDP increased from 9.6 per cent in 1999 to 9.7 per cent in the year 2002.[362] For a long time, it was the unavailability of good quality and reliable energy that have retarded industrial development in Uganda.

7.2.4 Mining

There is very limited activity in the mining sector. The major mineral of interest is cobalt. Petroleum exploration is still going on in the western region of Uganda. The Heritage Company is drilling in the areas that seem to be economically viable. So far no proven economic oil reserves have been found in the region.

There are reserves of iron ore and other minerals, most of which are not exploited because of the poor rail and power supply infrastructure. These call for high investment, which the government cannot afford. Most of these activities have been left to the private sector. Furthermore, Uganda will have to import reducing agents and other inputs to process the iron ore. Reducing agents like coal are available within the Great Lakes region. In 2002, mining and quarrying contribution to GDP was 0.7 percent.[363] In general the contribution of mining to the Ugandan economy will not be significant in the near future, unless viable petroleum reserves are located.

7.2.5 Population

The present population of Uganda is estimated at 24.6 million. It is estimated that the population is increasing at a rate of 3.4 per cent per annum. The urban population is increasing at a rate of 5 per cent while rural population is increasing at rate of 2.7 per cent per annum. It is estimated that by the year 2015, the total population will be 32.5 million.[364] It is also estimated that the urban population will constitute about 28.6 per cent of the total population by then. But according the recent survey,[365] the population could be over 35 million in 2015.

It should be stressed that the population will generally be rural in the foreseeable future. The Uganda Population density is 126 per square kilometre. This shows a drastic increase from 85 per square kilometre a decade ago.[366] The increase in the population will put pressure on the available biomass resources for energy use and land for agriculture. Sustainable use of energy is crucial for the rural poor who will have limited options for energy supply. For those with high disposable incomes, an appropriate energy mix should be developed so that less pressure will be exerted on the biomass resource base.

Acquired Immune Deficiency Syndrome (AIDS)

AIDS is one of the factors that have negatively affected the economy because it has caused the loss of experienced human resources, as well as resulted in a rise in number of orphans. Ophans usually grow with uncertainty of their future education and health. The government initiative, with assistance from international organisations has resulted in a reduction in infection rates over the last four years. The Human Immune Deficiency Virus (HIV) prevalence declined from 10 percent 1996 to 8.3 percent by 2000. [367] It is estimated that over 500,000 people have since died of AIDS and up to 2 million are HIV positive, which is about 10 per cent of the population.

Uganda's economy continues to suffer from the effects of Aids pandemic with the health and agriculture sector most affected despite the fact that the country has brought down the rate of infection.

A large percentage of agricultural land has been reverted to bush due to lack of labour to work on it. The pressure on agriculture by Aids is bound to reverberate through the entire economy, which is over 88 percent is dependent on agriculture. HIV/Aids has affected agricultural skills and output and led to loss of agriculture skills. Although Uganda has 0.4 percent of the world's population, it is said to have 2.4 percent of the Aids burden. A June 2002 report shows that 1.05 million people now live with Aids in the country. The worst affected belong to the reproductive age group between 15 and 39 years.[368]

Among the effects of the disease is loss of life, skilled human resource and increased levels of poverty. When the purchasing power of the population decreases and hence less energy consumption in the industrial and manufacturing sectors.

7.2.6 Investment

In 1987, the government of Uganda embarked on an economic recovery programme whose centrepiece was privatisation, followed by various institutional reforms. In 1992, the Uganda Investment Authority (UIA) was established as the sole agent responsible for facilitating and promoting private investment in the country. Initially incentives were introduced to attract investors. Tax holidays were based on investment: For investments of less than US$ 300,000 the tax holiday was not applied, but investments of between US$300,000 and US$ 500,000 would attract a tax holiday of three years, and above US$ 500,000 the tax holiday would be five years. In some cases, these concessions were subject to abuse and there were claims of unfair discrimination. However, investors preferred the tax holiday to the rapid depreciation of equipment. Since then, Central Government support to the private sector has changed focus to provide an enabling structure and environment rather than to provide direct subsidies or tax breaks to individual companies.[369] The Government is trying to improve the necessary infrastructure especially in the central region.

Constraints on Investment

Metropolitan Kampala accounts for 70.1 per cent of the total projected investment, followed by Jinja and Mpigi with 6.1 per cent and 4.4 per cent respectively. The other districts share only 20 per cent of the investment. There is a geographical imbalance in the spread of projects [370]. The average capacity utilisation was found to be 41.7 per cent. The main reasons for low capacity utilisation are the small markets, competition and financial constraints. Unstable supply of electricity was another constraint.[371] The national conversion rate (i.e. the difference between planned investment and final actual investment) is still 54.6 %, which is very low. Infrastructure is very important for project establishment. The main infrastructure includes electricity, water, roads and communications. In the survey carried out by the investment authority.[372] forty four per cent of the investors reported that electricity affected the investment negatively. The fluctuation of voltage damages machines and affects output quality.

Other factors that affect investment in Uganda negatively are fluctuating exchange rates, inflation, corruption, bureaucracy and unfair taxation. There has also been increasing dissatisfaction with changes in incentives. [373] At present the investment regimes include special initial allowances (accelerated depreciation) of 50-75 per cent on plant and machinery, import duty exemptions for plant and machinery and uniform corporate tax of 30 percent. Most of the investors prefer tax breaks to the present incentives. The investors find it difficult to borrow money from commercial banks. The interest rates are high. The commercial banks instead prefer buying treasury bills to risking lending to investors.

As a result of the power supply concentration, most of the industrial activities are concentrated around Kampala. This means that most of the upcountry towns will lag behind in terms of power supply and general economic development. These areas are characterised by poor basic infrastructure.

It also means that a major blackout in Kampala can paralyse the national economy. The high investment concentration in Kampala will increase pressure in the Capital City in terms of infrastructure needs. It may lead to increased environmental damage. The narrow roads of Kampala have led to traffic jams. The sewage treatment facility is too small for the rapidly expanding population of Kampala, and the drainage system is constrained.

7.2.7 Political Stability

There has been relative political stability over the last 19 years. Over the last decades, however the country experienced problems of insecurity. It should be noted that the issue of national security is very important for sustainable development at both regional and national levels. Some parts of northern Uganda have had the longest period of insecurity. This has led to extreme poverty, which is manifested in it being the least developed and the poorest of the four regions in Uganda. The infrastructure has been destroyed, and social, economic and family life severely disrupted.

Due to pressure from various sources, the government allowed parties to operate freely.[374] a sign of hope for smooth transition of power. The hope was however hinged on the premise that there would be no major changes in the constitution. It is imperative to note that any form of political instability undermines economic development. In such a situation, the investors loose confidence, and most likely leave the country. The level of unemployment rises as a result and less revenue is received by the government in terms of taxes. The lack of finance further destabilises the country. The electric power generated may not be sold, especially if the government commits itself to issues of power purchase agreements with independent power producers.

Recently in 2002, human right agencies like Amnesty International have reported that the Ugandan human rights record is not good. These and other related incidences may lead the country to turmoil. Furthermore the nation has been warned not to take security for granted. There will be less support from donors to supplement the national budget. The economic development and consequently energy consumption will reduce.

Lifting term limit for President Yoweri Museveni to stand again will be a setback to Uganda's democratisation, the United States government has said. The American government, in a comprehensive report to Congress, said the Government of Uganda made important progress in democratisation a year before, when, under court pressure, it relaxed restrictions on the operation of political parties. It said, however, that the progress could vanish when the third term Bill is passed. [375]

7.2.8 Poverty

Poverty eradication is one of the core programmes of government. The Uganda Poverty Eradication Action Plan (PEAP) of 2000 provided a framework for a policy frame work aimed at achieving four main goals:

- creating a framework for rapid economic growth and structural transformation;
- ensuring good governance and security;
- directly increasing the ability of the poor to raise income, and
- directly increasing the quality of life of the poor.

According to the Plan, security, roads, agriculture, research and extension and primary education were areas of high priority. PEAP was supported by the Plan for Modernisation of Agriculture (PMA). Sector-wide approaches were likely to be a major contributor to achieving the goals of PEAP. This was due to the fact that agriculture was and is still the largest employer and that there was scope for a rapid increase in productivity. It was clear that poverty alleviation would not be possible without modernisation of agriculture.

It is very important to address the causes of poverty as seen by the poor people. The issues are lack of income and assets to attain basic needs and vulnerability to adverse shocks and the inability to cope with them. To address the issues above, one has to think of people's assets, including land, physical and political influence over resources.[376] In most cases, issues of land and political influence over resources are not given serious consideration unless there is crisis.

According to the recent survey of household consumption and income, the proportion of the population living under the poverty line has dropped from 56 per cent in 1992 to 35 per cent in 2000. [377] Poverty is measured conventionally using an absolute poverty line based on consumption expenditure as a proxy for income. The percentage distribution of persons below the poverty line is shown in Figure 7.1.

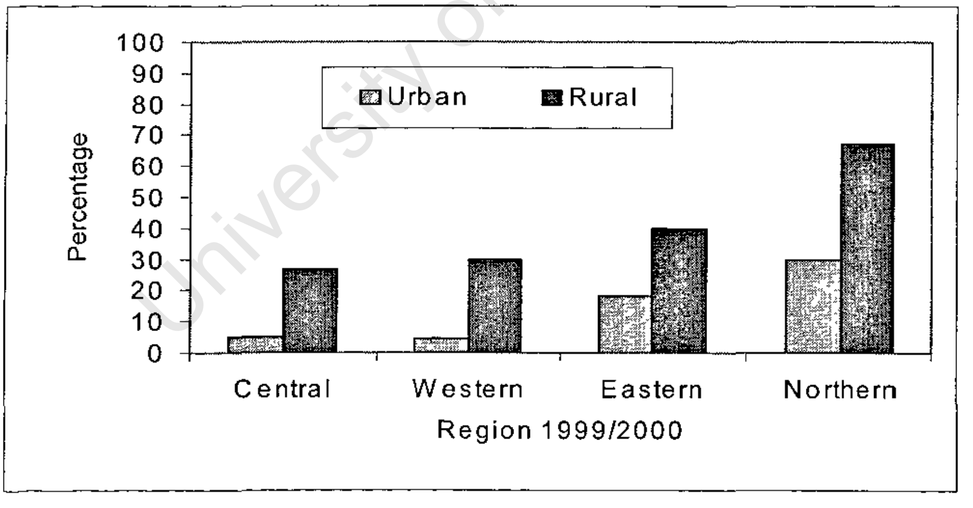

Figure 7.1 : Percentages of persons under the poverty line by region in urban and rural areas 1999/2000

The above figure was the result of a survey carried out during the Uganda National Household Survey in 1999/2000.[378] The poverty situation in Northern Uganda is alarming. The energy consumption in that region is the lowest in the country. Central region has the lowest number of persons below the poverty line.

These poor peasants rely heavily on biomass, and this causes serious health problems due to indoor air pollution and environmental degradation, since they are too poor to afford any other forms of energy. At present, the peasants rely on dead wood and agriculture residues as the main source of household energy. There is a lack of energy and finance to facilitate processing, storage and cold room facilities that could add value to primary agricultural products in the rural areas.

7.2.9 Macroeconomic Stability

With respect to macro-economic policies, the government strategy is to modernise the economy by relying on the free market and the efforts of private entrepreneurs. The government has provided the legal, policy and physical infrastructure necessary for private investment to flourish. The central objective is to facilitate sustainable, rapid and broad-based growth by guaranteeing security, rule of law and structural reform.

The monetary and fiscal policies remain stringent to achieve an annual inflation target of five percent. The budget deficit for the fiscal year 2001/02 is projected at two percent of GDP. The budget is heavily funded by external grants. The national image is very important if the country is to continue receiving Aid. The tax collection is too low to support the economy. It is coupled with corruption in the Uganda Revenue Authority, the sole body responsible for the collection of taxes. The tax base is narrow, the domestic revenue to GDP ratio at 11.6. It is 12 per cent below most Sub-Saharan African countries, where the average ratio is 20 per cent. [379]

7.2.10 Corruption

The issue of corruption is a major worry not only to nationals, but also to the investors and the international donors. The Berlin-based Transparency International ranked Uganda as the 13th most corrupt country in 1999. The most recent report by the same organisation ranks Uganda as the 2nd most corrupt country, after Nigeria. The World Bank also warned that growing corruption could affect donor or investment confidence in Uganda's future. The corruption is widespread in Uganda.[380]

Corruption affects all sector of economic and social development of a country. It is estimated that Ugandan government officials steal US$ 200m from national coffers annually.[381] Nearly half of the budget is supported by donors. A cutback in support to the national budget by the international donors will have a negative effect on the economy and energy consumption.

7.2.11 External Debt

Uganda is heavily indebted, the amount having risen from US$ 2,689 million in 1991 to US$ 3,785 million in 2002.[382] Indebtedness has caused over-dependency on external donor funding for the national budget. In 1998, the external debt was US$ 3,935 million. The official development assistance was US$ 23 per capita, which was about 7.0 per cent of GNP.[383] Should there be a slow down in the worldwide economy, the country will be hard hit. The provision of basic needs like health and other social services will be curtailed. The total debt stock reached US$ 4.553 billion in 2003.[384]

Uganda is among the 18 least developed countries whose debt may be cancelled following the Ministerial meeting of eight most industrialised nations. The current debt stock stood at US$ 4.76 billion. Uganda may benefit by having US$ 3.81 of its external debt written off.

The government had committed itself to various energy projects like Power IV. The main objective of the Fourth Power (Power IV) project is to address the medium-term problem of electrical power shortages through the installation of the remaining three generating units at Kiira hydropower station, for which major civil works are already being undertaken under the Power III project. However, the inability of government to settle debt obligations negatively affects the power sector as the government will need to borrow from international banks.

7.2.12 Regional Stability

There is still instability in the region within the neighbouring countries namely the Democratic Republic of Congo and Southern Sudan. Uganda has traditionally been accused of interfering in the affairs of neighbouring countries. In 2001, the accusation came from Rwanda in 2001 and between 2000 and 2002 it came from the Democratic Republic of Congo, while more accusations came from Sudan. Uganda's involvement in the civil conflicts in the neighbouring countries has put pressure on the national budget. The government pledged to cut military spending to two per cent of GDP in the fiscal year 2001/02. [386] Permanent regional peace would help in the reallocation of public expenditure towards rural /social development.

It is also envisaged that the instability in these countries may spill over into Uganda. Worst of all, the continued conflicts may cause Uganda's intervention in these conflicts and increase military expenditure. Yet the donor countries are always cautious about military expenditure. With increasing military expenditure, the social sectors like health and education will likely have less allocation in the national budget.

In 1997, Uganda military expenditure was 4.2 per cent of gross national product (GNP), while that of Kenya and Tanzania was 2.1 per cent and 1.3 per cent respectively. The average value for Sub-Saharan Africa was 2.3 per cent of GNP. [387] The instability in Rwanda and the Democratic Republic of Congo has discouraged multinational companies, which normally target large investment in selected countries with the aim of serving a wider regional market.

The Uganda involvement in Congo, which started as protection of the villages along the border, has developed into a hunt for diamonds and other riches. This has had a direct effect on donor aid as release of more funds by donors is perceived as likely increase the hunt for diamonds and further destabilisation of the region. [388]

7.2.13 Regional Corporation

A number of developments have taken place to operationalise the Treaty for the Establishment of East African Community (EAC) that came into force July 7^{th}, 2000. The EAC is led by the East African Legislative Assembly. The proposed revitalisation of the EAC is expected to create a market of 100 million people.

Energy supply and planning could be done jointly so that a large infrastructure would be created in the region. It is deemed easier to obtain funds for such multi-national projects than for small projects in individual countries.

The present EAC seeks to create an enabling economic and business environment in which the private sector will feature prominently. Uganda wants a national objective which is specific, measurable and achievable, realistic, and time bound in order to avoid pursuing unattainable goals. Uganda may have a comparative advantage in power supply, whereas Kenya commands better infrastructure and lower energy costs. There are a number of activities under consideration including the East African Road Network Project; East African Digital Transmission, East African Civil Aviation Safety Project, East African Master Plan and The Lake Victoria Development Program. It is anticipated that completion of these projects will contribute to socio-economic development in the region through enhancing communication and mobility and management of common services. It is imperative to note however that the EAC will function well as long as leaders do not interfere in the internal affairs of neighbouring countries. The spirit should be formed in the interest of the population and not necessarily because of friendship among the leaders. This is however likely to change because of the prevailing political climate.

7.2.14 Human Resource Development in Energy and Environment

Capacity building in the Ministry of Energy and Mineral Development (MEMD, NEMA) is still limited. The challenges that are faced in the energy sector are too great to be managed by the current staff. The situation has been worsened by the ban on recruitment of staff in the ministry. The government lacks the capacity to finance larger institutions. There is an ongoing effort to reduce the workload at Ministry level.

There are other institutions, like NEMA, which have crucial roles in monitoring the environment. However the Ministry remains with the work of policy formulation and monitoring. Under the decentralisation program most of the work is handled at district level. The staff at district levels has of to date not received adequate training to handle energy-related issues.

7.2.15 Environment

Climate Change

Uganda is mainly an agricultural country, with about 84 per cent of the population living in the rural areas and depending on land for their livelihood. The dependence of a substantial part of the Ugandan economy on climate-related events such as rain-fed agriculture, livestock and hydropower, places this country in a vulnerable position in the event of serious climate change. Most likely, future economic development will depend on the exploitation of natural resources, notably for commercial agriculture, mining and hydropower. Climate change threatens diminishing resource allocation and may create conflict and tension between agricultural, industrial and commercial sectors.

Climate change will have serious effects on energy supply in Uganda in particular, and the East African Region in general. Most of the water received in Lake Victoria is due to rainfall on Lake Victoria and the River Kagera supply is about 35 percent of the water resources. Although there are numerous tributaries that feed Lake Victoria, they do not contribute much to the lake. All the proposed major dams are located along the River Nile. With any climatic change likely results will be reduction in water flow, affecting power supply. It is also likely that the small hydropower plants will face sedimentation, which will lead to the reduction of power production.

Climate change is expected to alter the weather patterns primarily through changes in temperature and precipitation. The most significant effect will be changes to timing and length of planting/sowing seasons. These changes adversely affect the agriculture sector, the GDP, and food security. The effect may not be limited to food crops but may extend to scarcity of fuelwood. Such changes are already evident in the cattle corridor of Uganda where there is a threat of desertification.

7.2.16 Critical Factors

Although future energy demand depends on many factors as stated in the previous sections, the critical factors that influence energy demand are population, politics, and land use, national and regional economics, technology and availability of natural resources.

The number of people in a given geographic area has a direct impact on the energy need of that area. The population growth in both rural and urban areas affect fuelwood and charcoal needs. Further, land use is a key factor affecting energy use. The population density can affect the land use and character of energy use. Political stability in the country and within the neighbouring countries affects trade. All these factors have a direct impact on the GDP. The general condition of the economy has a direct influence on energy demand as technological advances are normally accompanied by overall reduction in specific energy.

7.3 Scenarios

Uganda has gone through political upheaval and development under different regimes. The data given reflects the general GDP growth rate in real terms under different government regimes. The highest GDP was attained in 1994 in the present regime and the lowest was under Amin regime in the late 1970's. During this regime, considered as status quo, the lowest real GDP growth rate was 4.5 % and the highest was 10.4, therefore in the long run it will stabilise at 4.5 %. In the Enhanced Scenario the real GDP growth would stabilise at 8.5%. In the worst case, if there is political instability the GDP growth rates would be 2%.

In the regular energy demand projection, in most cases it is simply extrapolated from historical growth curves as the result, it gives us one projection it ignores the effects of changes in the environment. In some cases, such as in econometric and optimisation models, it requires a strictly formulated logical and mathematical presentation. But in the scenario based projections there are issues such as social, environmental and political aspects are also taken under consideration. Consequently the energy demand projection will be lying within a given range as described by the scenarios. That is why Scenario based approach was used.

GDP is the main factor that determines the development of a country. The growth in GDP reflects the economic development. The GDP growth rates can be affected by many factors, some of which can be used to develop scenarios.

Status quo Scenario

The GDP growth rates have been varying between 6% and 5 % per annum over the last decades. The number of investors have been increasing hence more jobs created. This has resulted in an increase in the per capita income. Although there are some unstable governments within the region, there is quasi stability in Uganda. The partners in development have assisted the country by financing about 52% of the national budget and cancelling some of the national debt. All these factors steer Uganda towards a sustainable development goal.

Uganda has the lowest electrification rate in Eastern Africa. Recently there has been frequent load shedding. This means that the amount of investments will decrease. There is little effort done in the areas of afforestation and reforestation programmes. This has a negative impact on sustainable development.

Enhanced Scenario

Uganda attained the highest GDP growth rates of 10.4 % per annum in the mid 90's. It is envisaged that the country could attain a GDP growth rate of 8.5 % per annum if the country attained stable governance, rule of law and favourable long term policies. There are a lot of opportunities at the regional level, implying that Uganda could benefit if there is stability and a regional government.

With stable governance, the investors gain confidence, paving the way for development of infrastructure and creation of jobs. Furthermore with a stable government it is easier to obtain loans and grants for infrastructure and social-economic development. The country could be assisted by development partners to implement some of the policies relating to the environment, like afforestation and reforestation programmes. If the above is put in place, Uganda can achieve its sustainable development goals.

Low Case Scenario

Uganda is characterized by turmoil and military coups that have often led to serious economic and social problems. This is manifested in unpopular and unstable governance, unpopular economic and political decisions and suffering of the population. The situation could be exacerbated if the present stable micro economic policies are reversed. This gives rise to high inflation and low human development. In such circumstances the GDP growth rates could be retarded (as low as 2% per annum). The on going efforts to increase the number of connections to the grid may be retarded. This results in low investment opportunities.

The situation could get worse with political instability. The regional government may likely intervene and this may in turn most likely cause regional hostilities. The development partners may withdraw their financial support. The government of the day may not care about issues related to the environment. The biomass resource base may not be maintained, or may be poorly managed, with a low level of afforestation and reforestation. As a consequence, there may be over exploitation of natural resources resulting in environmental degradation. Under these circumstances, Uganda may not attain sustainable development.

The population and GDP are the major parameters for energy forecasting. It should be noted that some of the parameters affecting the GDP cannot be computed. The political situation in the region is very unpredictable, and its contribution to GDP cannot be quantified. Nevertheless, GDP gives a broad indicator of the situation under analysis.

The important drivers that are used in the three scenarios that have been modelled as part of this work are summarised in Table 7.1 below.

Table 7.1 : Important Drivers for Scenario Development

Parameter	Status quo Scenario	Enhanced Scenario	Low Case Scenario
GDP in long run	4.5%	8.5%	2.0 %
Access to grid electricity in 2025	9 %	12 %	6 %
Governance	Quasi stable	Stable	Unstable
Regional governance	Not stable	Stable	Hostility
External debt	Not sustainable	Sustainable	Not sustainable
Environment	Degrading	Sustainable	Degraded

7.4 Projected Energy Demand by Sector

The energy demand was divided into four sectors namely; household, industry, commercial and the transport sector. Energy use in agriculture is mainly for ploughing. When diesel is purchased, it is not only for ploughing but also used in transport and diesel electrical generators. Therefore it is not easy to establish energy used in the agriculture sector.

The high average growth rates in energy demand and GDP seen over the last decade may not be achievable in the future. The real GDP growth rate of 4.9 % in 2002 was the lowest in the last 13 years. There have been declines in petroleum demand growth rate over the last three years.

7.4.1 Population and Energy Demand Projection

Population growth rates have many implications in biomass energy demand because it is the main source of energy for most of the people. The biomass energy demand for household is proportional to population growth rates. Presently, the population growth rate is 3.4 % per annum. In the base year 13% of the population were living in the urban areas and 87% in rural areas. The national population projection is based on the Status quo Scenario.

It was estimated that the population of Uganda will be 22.2 million in 2000 [389] and would increase to 40 million [390] by the year 2025. The assumption was based on annual population increment of 2.5 % per annum. In 2002, the population was 24.6 million which was higher than the projected 23.5 million. [391]
If Uganda maintains the population growth rate of 3.4 % per annum, the population would increase from 22.45 million in the base year to 53.55 million in the year 2025. Thus, Uganda's population is projected to double by 2020.

The Households
The total number of households was expected to grow at about the same rate as the population. The number of persons per household in the rural and urban areas was 5.4 and 4.4 respectively. The number of the people per household is higher in the rural areas than in the urban areas because of the economic hardship. The number of the households would increase from 4.27 million in 1999 (the base year) to 10.19 million by the year 2025. The number of household in the urban areas is expected to grow faster than in the rural areas. That is because there is a steady migration to the urban areas due to improved economic development in the urban areas and worsening economic situation in the rural areas

7.4.2 Economic Projections
It is important to note that the future is inherently unpredictable, and the scenarios stated here, are only assumptions, highlighting possible events. The most preferable scenario is one with a vibrant economy, improved human resource development and stability within and with neighbouring countries. The main driving force is the future political situation,

which nurtures economic progress. Over the last decade, the highest growth in GDP was 10.4 % in 1994,[392] but it may not be achievable for a long period.

At present the political situation is relatively stable, but there are still some areas where there is insecurity. There are some countries within the Great Lakes Region such as The Democratic Republic of Congo, Burundi and Sudan that have not attained political stability. In spite of political stability in Uganda for the last three year, there has been a steady decline of the economy. In this study, it was assumed that GDP growth rates would vary depending on the scenario under consideration. The growth rate for GDP is as shown in Table 7.2.

Table 7.2: GDP growth rates in percentage for (1999-2025)

Scenario	1999-2005	2006-2010	2011-2015	2016-2020	2021-2025
Status Quo	5.5	5.5	5.5	4.5	4.5
Low Case	4.5	3.5	3.0	2.2	2.0
Enhanced	6.5	7.5	8.5	8.0	7.5

It is indicated that the GDP growth will be decreasing, assuming that GDP will stabilise in the long run, at 4.5 % per annum. In 1999 (the base year) the GDP is US$ 6.349 billion. In the Status quo Scenario, the GDP would double in 2012 and increase 3.6 fold to US$ 23.55 billion by the year 2025. In the most favourable case, the Enhanced Scenario, the GDP will reach US$ 42.58 billion by the year 2025. At the other extreme is the Low Case Scenario, where the stable political environment is eroded and a non-competitive economy emerges. The government fails to pursue economic policies that are conducive to sustainable economic growth. The quest for power compels the political leadership to focus on their political credibility at the expense of economic growth and development. That will result in low growth rates and the GDP will grow to US$ 13.68 billion in 2025. These three scenarios are presented by the growth rates in GDP as shown in Figure 7.2.

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Enhanced	6.5	7.5	8.5	8.0	7.5

It is indicated that the GDP growth will be decreasing, assuming that GDP will stabilise in the long run, at 4.5 % per annum. In 1999 (the base year) the GDP is US$ 6.349 billion. In the Status quo Scenario, the GDP would double in 2012 and increase 3.6 fold to US$ 23.55 billion by the year 2025. In the most favourable case, the Enhanced Scenario, the GDP will reach US$ 42.58 billion by the year 2025. At the other extreme is the Low Case Scenario, where the stable political environment is eroded and a non-competitive economy emerges. The government fails to pursue economic policies that are conducive to sustainable economic growth. The quest for power compels the political leadership to focus on their political credibility at the expense of economic growth and development. That will result in low growth rates and the GDP will grow to US$ 13.68 billion in 2025. These three scenarios are presented by the growth rates in GDP as shown in Figure 7.2.

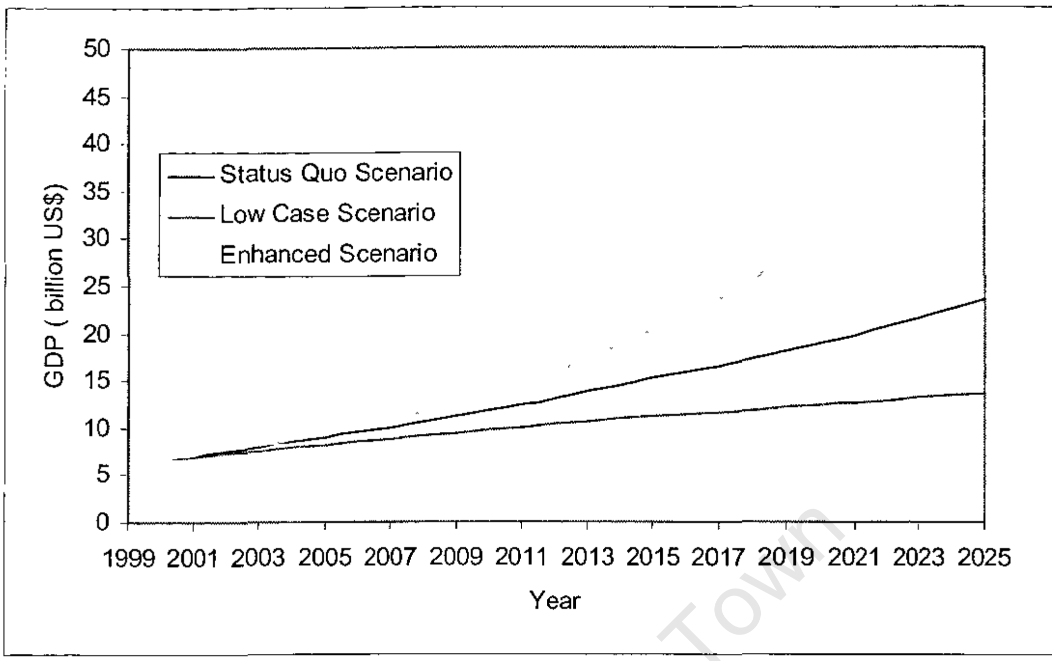


Figure7.2: GDP Projections using different scenarios

In the best scenario, the GDP was projected between US$ 80 US$ 70 billion by the year 2025. [393] The GDP of US$ 80 billion will not be achieved unless the country can increase exports of products. If petroleum exploration is successful, there is an opportunity to attain a high GDP.

The national GDP per capita was given as US$ 320 in 1999. The projected GDP per capita growth rates is as shown in Table 7.3.

Table 7.3 : GDP per capita growth rates in percentage for (1999-2025)

Scenarios	1999-2005	2006-2010	2011-2015	2016-2020	2021-2025
Status Quo	2.4	2.0	1.7	1.5	1.5
Low Case	2.4	-1.1	-1	-0.9	-0.9
Enhanced	2.4	3.5	4.1	4	3.8

The percentage increase in GDP per capita will depend of the same factors as GDP increment. In the Status quo Scenario, the GDP per capita is expected to increase from US$ 320 in the base year to US$ 506 in 2025. In the Enhanced Scenario, the GDP per capita would reach US$ 804 by the year 2025. The highest GDP was US$ 2,000 and the lowest was US$240. [394] It is unlikely that the highest GDP of US$ 2,000 per capita is achievable. A lower population growth rate of 2.5 % per annum has been assumed in the studies made by the household survey and population census in 1990. The projected per capita income projection for different scenarios is given in Figure 7.3.

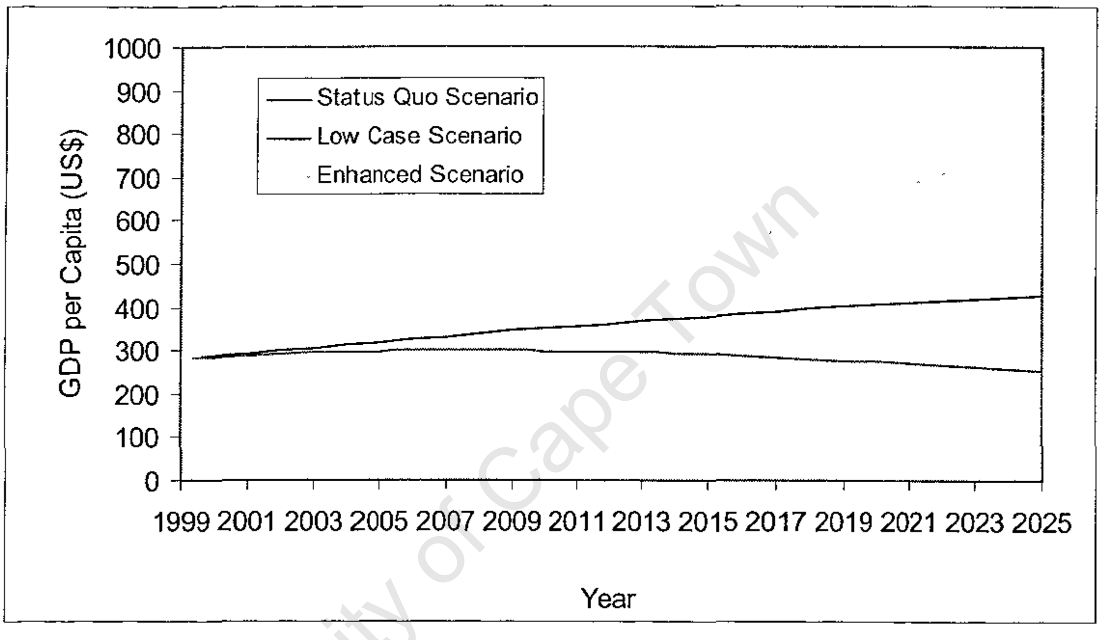


Figure 7. 3 : Real GDP per capita income projections under different scenarios

In the Low Case Scenario it is assumed that the GDP per capita would be US$ 248 by the year 2025. The economic situation will be worse than in the base year. There is a high population growth rate, coupled with poor economic performance.

7.5 Energy Demand Projection

Energy demand projections assume that energy consumption is basically determined by the level of economic development and by the growth rate of the population. The dependency of energy demand on economic development was modelled as a direct relationship between demand and GDP or population.

The energy demand was divided into four sectors namely, households, industry, commercial and transport. Unlike other countries, there was no separate data for the agricultural sector, but it was integrated within other sectors. The main sectors were divided into sub sectors. Three different scenarios considered for the projected energy demand.

Electricity demand is higher than supply. Various studies done by various consultants in the recent past agreed that the current demand for power far exceeds the available generating capacity. These studies include the National Electrification Planning Study (NEPS) prepared by EDF in 1991; the Extension of Owen Falls Power Station Study by Acres of Canada in 1990; the Hydro-Power Master Plan by Kennedy and Donkin in 1996; as well as the most recently released Optimisation Study - Load Forecasts by EDF, September 1998. The EDF study estimated that the current rate of growth of electricity demand surpasses that of the overall economy by about five percentage points every year. This results in load shedding in all sectors and yet electricity is only accessible to about 4.3% of the population. [395] Furthermore, from the consumption data over the last decade there are no clear trends to determine the growth rates as shown in Figure 2.5. In order to establish the demand at the base year the electricity consumption as determined during the survey; load shedding, non-technical losses and suppressed demand were the considered factors.

It is important to note that generally, the projected energy demand for a given sector is based on the parameter under consideration. For example, for households it depends on the rate of increase in connections while for other sectors depends on the economic performance. Another important parameter that effects consumption of electricity is tariff structure.

National Energy Demand

In the Status quo Scenario, the total energy demand is expected to increase from 280 PJ to 726.2 PJ by 2025. In the Low Case Scenario, the total energy demand will be 648.1 PJ, while in the Enhanced Scenario the energy demand will reach 781.4 PJ. The energy demand in the Enhanced Scenario is similar to the Status quo because it was assumed that there would be changes in energy intensity due to improvement in appliances used mostly for cooking. The trend in energy demand is as shown in Figure 7.4.

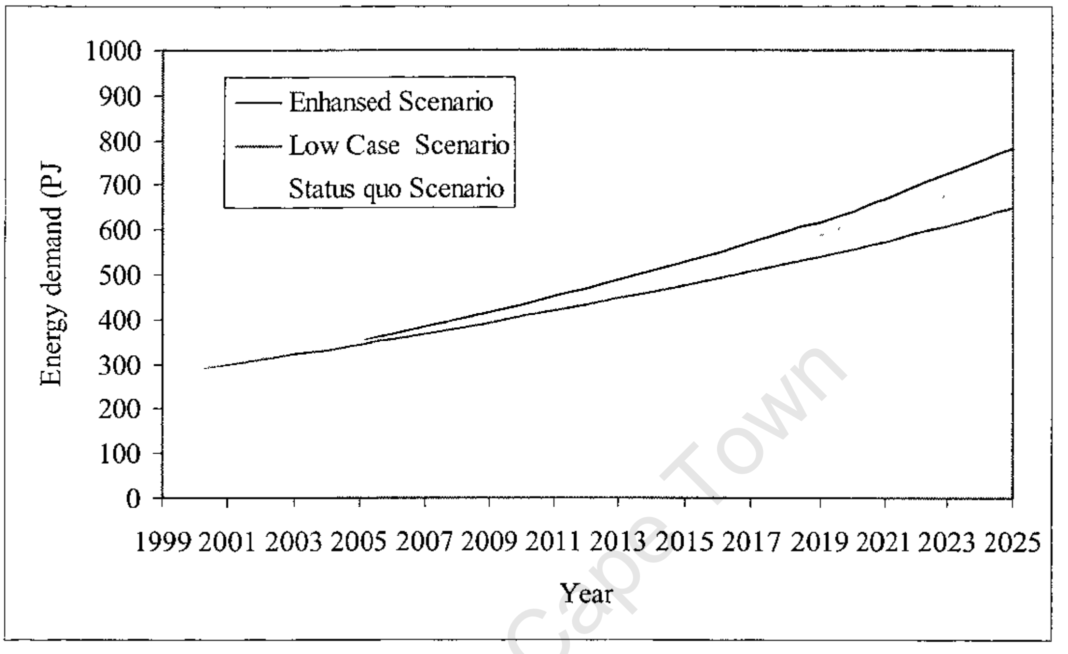


Figure 7.4: Trend in total energy demand (1999-2025)

Biomass is expected to the leading source of energy in Uganda up to 2025. The energy mix in 2025 for the three scenarios is as shown in Table 7.4.

Table 7.4 : Energy mix for Uganda in the year 2025

Energy Source	Status quo Scenario	Enhanced Scenario	Low Case Scenario
Biomass	83.9 %	78.9 %	88.1 %
Electricity	3.0 %	4.0 %	2.5%
Petroleum	13.1 %	17.1 %	9.4 %

Petroleum products will be the second largest energy source for Uganda. The use of electricity will be the lowest because of the high cost associated with development of hydropower plants and high operational cost of thermal power plants. In the low Case

Scenario, the use of biomass is highest among the three scenarios because there is a limited resource to develop other alternative sources of energy.

7.5.1 Household Energy Demand

The projected energy demand for all sources of energy was based on the household survey. Different parameters were used to project household energy demand depending on the applications of the energy sources. The growth in biomass consumption in the households is assumed to be proportional to the population growth rates. For the household sector, future biomass energy demand was assumed to be proportional to the growth in number of households in each of the three scenarios and continued urbanisation and rural electrification.

The electric energy consumption in households is proportional to the increase in connection rates. The total number of households is expected to grow at the same rate as population growth in the urban and rural areas.

Electricity demand in households

The predicted electric energy demand in households exceeds the supply. The demand was built up from the following parameters: energy consumption from the household survey, of private generators, suppressed demand and estimated non-technical losses (theft of electricity). The detail of the build up of electric energy demand in the household sector is as shown in Table 7.5.

Table 7.5: Electric energy demand in the household sector

Components of energy demand	Energy demand (PJ)
Energy consumption from survey	1.155
Suppressed demand(derived from load shedding)	0.108
Private generators	0.047
Non-technical losses	0.090
Total energy demand	1.400

The estimated total electric energy demand is for the base year. This was 1.4 PJ. The energy consumption obtained from the household energy survey was increased to account for the differences between energy supply and demand. The difference was approximately 18 %. It was assumed that all categories of households are affected equally by load shedding. The energy demand in the base year was multiplied by 18 % to obtain the estimated electric energy demand. It was assumed that in all three scenarios, low-income households whether in rural or urban areas, would have very limited access to grid electricity. The average number of new connections and reconnections was estimated at 14,500 per annum. That shows a growth rate of about 9.76 % per annum in the Status quo Scenario. The highest number of connections and reconnections achieved was 20,603 per annum. In this study it was assumed that the highest number of connection achievable is 17,500 customers per annum. This implies a growth rate of 11.8 % per annum, the increment assumed for the Enhanced Scenario.

In the Low Case Scenario, it was assumed that the growth rate is 8 % per annum. The growth rates improve as the economy and availability of electric energy increases. The estimated connections per annum for the three scenarios are as shown in Table 7.6.

Table 7.6 : Estimated household connections per annum for the three scenarios

Scenarios	Connection per annum	Percentage
Status quo Scenario	14,500	9.76%
Enhanced Scenario	17,500	11.78 %
Low Case Scenario	12,000	8 %

The growth rates in household connections are as shown in Table 7.7.

Table 7.7 : Household connection growth rates (%) for three scenarios

Scenarios	2000-2004	2005-2009	2010-2014	2015-2019	2020- 2025
Status quo	9.76	8	7.5	6.5	5
Low Case	8	6	6	5	4
Enhanced	11.78	9.5	8.5	7.5	6

The growth rates are hinged on the premise that there is an on going plan to install two more turbines with a total installed capacity of 80 MW at the Kiira Hydro Electric Power Station within two years. The number of households connected to grid based electricity will increase, as more electricity becomes available. The estimated number of households connected to the grid up to the year 2025 is as shown in Table 7.8.

Table 7.8 : Estimated number of households connected to national grid

Scenario	2000	2005	2010	2015	2020	2025
Status quo	162,920	255,373	373489	531,204	717,545	915,790
Low Case	160,308	231,183	309374	415,966	525,833	639,757
Enhanced	165,918	283,638	442437	653,010	924,399	1,237,055

The estimated number of households in the year 2025 is 10.19 million. This implies that in the Status quo Scenario only 9% of the total households would be connected to grid electricity. In the Enhanced Scenario only 12% of the households would have access to grid electricity by the year 2025. This implies that even at such high connection rates, the level of grid-based electrification will still be low in the foreseeable future.

Electric energy demand for the household sector out-strips supply. The number of new connections will increase as the country develops its hydropower potential. There will still be a number of households relying on car batteries and photovoltaic as the main source of electricity mainly for light and household appliances. The projected demand of electricity is as shown in Figure 7.5.

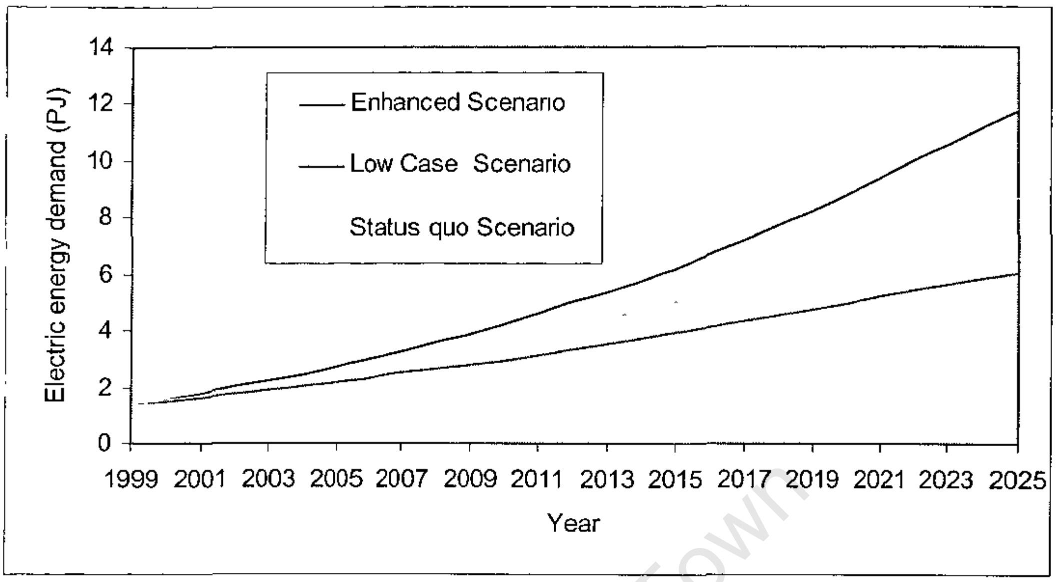


Figure 7.5 : Projected electric energy demand for three scenarios

In the Status quo Scenario, most of the households will use electricity for lighting and few households will use it for cooking. In this scenario electric energy demand will increase from 1.4 PJ in the base year to 8.7 PJ by the year 2025. In the Enhanced Scenario, it was assumed that the number of wealthy households will increase and so will the number of connections. In this case, electric energy demand will reach 11.7 PJ by the year 2025. In the Low Case Scenario, the number of households connected will be the least of the three scenarios. As the result, energy demand would be 6.07 PJ in 2025.

The projected energy demand made by the EDF study in the year 2000 shows that domestic energy demand would be 5.4 PJ in the year 2020, while the most recent study made by EDF in 2001, projects domestic energy demand at 8.18 PJ by the year 2020. In this study the household energy demand is 6.81 PJ. Note however that both studies quoted above made projections for only one scenario.

Status quo Scenario

This scenario assumes that there is a gradual improvement in the households' income. The high population growth rate and the high dependency on wood fuel are maintained.

The majority of the households will live in the rural areas and only 20% will be in the urban areas by 2025. The total energy demand will be 518 PJ. Electricity consumption will be 1.7 % of the total energy demand. The projected number of households connected to the national grid up to the year 2025 is as shown in Table 7.9.

Table 7.9 : Projected number of households connected to the grid, Status quo Scenario

Rural Household	2000	2005	2010	2015	2020	2025
Medium Income	3,939	6,174	9,030	12,843	17,348	22,141
High Income	8,612	13,498	19,742	28,078	37,928	48,407
Urban Household						
Medium Income	83,349	130,648	191,075	271,762	367,093	468,514
High Income	67,020	105,053	153,642	218,522	295,177	376,729

Enhanced Scenario

In this scenario, it is assumed that the rural household income would have improved and the availability of different sources of energy has increased in most of the areas. It is assumed that programmes like rural electrification and poverty eradication have taken root and the rural community feel their impacts. There will be a high rate of urban immigration. The energy demand will reach 495.8 PJ in 2025. Electricity consumption will be 2.4 % of the total energy need. The total energy demand is lower than in the Status quo Scenario because of higher demand for high quality energy like charcoal. The projected number of households connected to the national grid up to the year 2025, is shown in Table 7.10.

Table 7.10: Projected number of grid connected households; Enhanced Scenario

Rural Household	2000	2005	2010	2015	2020	2025
Medium Income	4,011	6,857	10,697	15,787	22,349	29,908
High Income	8,770	14,993	23,386	34,517	48,862	65,388
Urban Household						
Medium Income	84,883	145,108	226,349	334,077	472,918	632,871
High Income	68,254	116,680	182,005	268,629	380,270	508,888

Low Case Scenario

The Low Case Scenario is the least desirable situation where the energy demand is expected to reach 493 PJ by the year 2025. Electricity consumption will be 1.2 % of the total energy need. There is a relatively low rate of urbanisation of about 5.0 % per annum. The projected number of households connected to the electricity grid up to the year 2025 is as shown in Table 7.11.

Table 7.11: The projected number of households connected to grid, Low Case Scenario

Rural Household	2000	2005	2010	2015	2020	2025
Medium Income	3,624	3,998	5,350	7,193	9,093	11,064
High Income	7,924	8,741	11,697	15,727	19,881	24,189
Urban Household						
Medium Income	76,697	8,4600	113,214	152,220	192,425	234,115
High Income	61,672	6,8026	91,034	122,399	154,728	188,250

Most of the households depend on biomass. Commercial fuel is the least used among the three scenarios. The projected energy demand for the three scenarios is as shown in Figure 7.6.

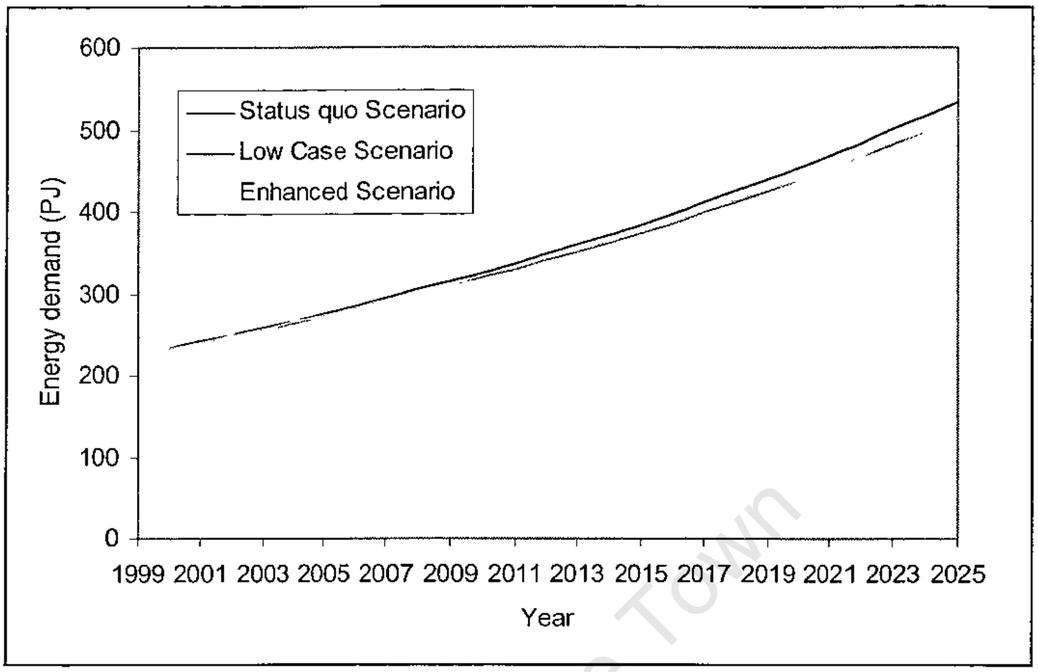


Figure 7. 6 : Projected energy demand for the three scenarios

The total energy demand in the Enhanced Scenario is lower than the Status quo Scenario because of rapid immigration to urban areas. In the Enhanced Scenario, there is more use of modern energy and more efficient appliances in the household. The dependency on fuelwood has decreased while the consumption of modern fuel with high calorific values increased.

Energy Mix for Household

Biomass is the dominant source of energy source for households. Particularly, charcoal is the leading commercial fuel in households. The dominance of biomass in household energy mix is evident as shown in Table 7.12.

Table 7.12 : Energy Mix for Households

	SCENARIOS		
Fuel sources	Status quo (%)	Enhanced (%)	Low Case (%)
Wood fuel	82.0	78.4	78.5
Agricultural waste	5.1	2.7	10.2
Commercial fuel	12.9	18.9	11.3
Total	100	100	100

The use of commercial fuel will increase with the increasing well being of the household. The use of agricultural waste will also decrease as the household income increases.

7.5.1.1 Rural Households

In the Status Quo Scenario, the total rural household energy demand is projected to increase from 205.9 PJ in the base year to 456.7 PJ, while in Low Case Scenario; it is estimated at 435.3 PJ by the year 2025. The Enhanced Scenario leads to high rates of urbanisation, increased use of commercial energy and the demand is estimated to reach 409.1 PJ in 2025. The projected energy demand for the three scenarios is illustrated in Figure 7.7.

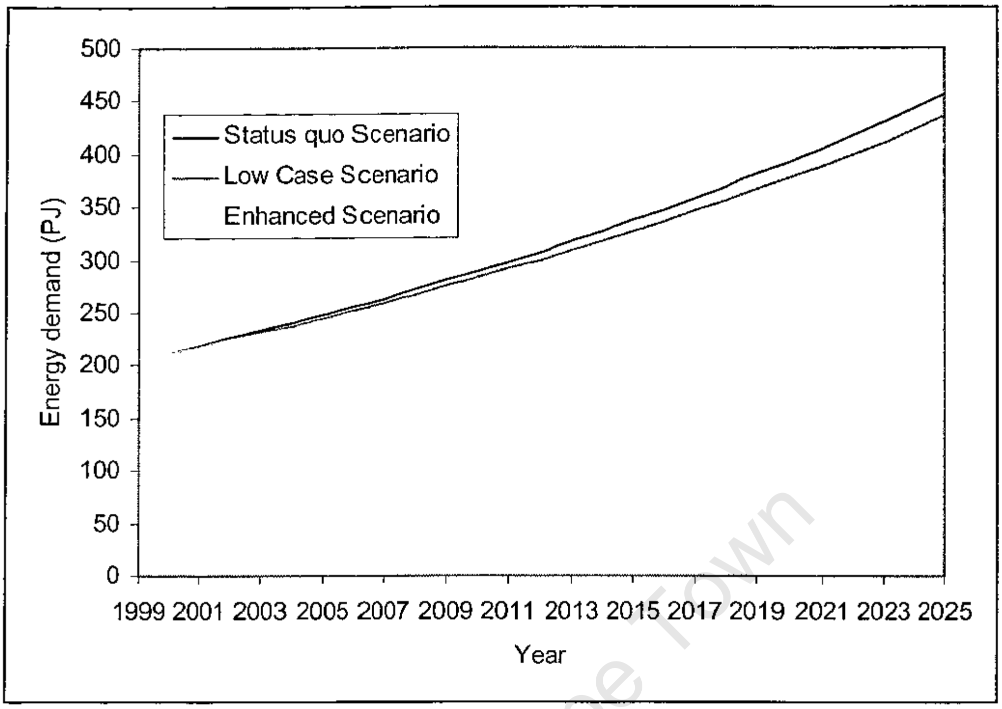


Figure 7.7: Projected energy demand for rural household

In the Enhanced Scenario, the energy demand in the rural area is lower than in the Low Case Scenario because of higher rates of urban immigration. The scenario also assumes that most of the households, especially those in rural areas use less efficient households appliances. The main source of energy for cooking is presumed to be biomass. The use of agriculture waste will increase while the use of charcoal increases mostly in high and medium income households. The use of commercial fuel for instance electricity, LPG and kerosene will increase with increasing income. The energy mix for the three scenarios for rural households in the year 2025 is given in Table 7.13.

Table 7.13 : The Energy mix for the three Scenarios

	SCENARIOS		
Fuel sources	Status quo (%)	Enhanced (%)	Low Case (%)
Wood fuel	91.1	93	86.9
Agricultural waste	6.8	3.2	11.4
Commercial fuel	2.1	3.8	1.7
Total	100	100	100

In all three scenarios, the use of biomass is the leading source of fuel for cooking followed by agricultural waste. In the Enhanced Scenario, the use of agricultural waste is reduced, but the use of commercial energy increases. This is due to the increased income in the rural households. In the Enhanced Scenario, the rural household have more access to modern forms of energy and there will be relatively less dependency on fuel wood. In the Low Case Scenario, use of agriculture waste is the main supplement to wood fuel.

Low Income Households

Low-income households depend on firewood and agricultural wastes for cooking. kerosene is mainly used for lighting. A few households use grass for lighting. The dependency on agricultural waste increases with scarcity of wood fuel.

Status Quo Scenario

Taking the status quo scenario, most of the rural households depend on woodfuel and agricultural waste for cooking. The percentage of low-income households gradually decrease from 32% to 25%. That is from the base year (1999) to 2025. The total energy demand for the sector increases from 62.5 PJ to 109.8 PJ. The percentage of households that use three stone stoves for firewood increases from 88 % to 90 % (from the base year (1999) to 2025. The woodfuel demand increases from 54.2 PJ to 93.17 PJ. The low increase in energy demand is due to the decrease in the number of low-income households over time. Agricultural waste account for 15 % of the total household energy need. The use of kerosene for lighting is 0.36 PJ.

Enhanced Scenario

In the Enhanced Scenario, income of the households would have improved. The percentage of low-income households decrease gradually from 32% to 15%. That is from the base year to 2025. The total energy demand for the sector decrease from 62.5 PJ to 58.8 PJ. The percentage of households that use three-stone stoves for firewood will increase from 88 % to 90 %. The rest of the households use agricultural wastes. The demand for woodfuel decreases from 54.2 PJ to 51.83 PJ 2025. The decrease in energy demand is due to a decrease in the number of low-income households. Agricultural waste accounts for 7.8 % of the total household energy need. The use of kerosene for lighting is 0.22 PJ.

Low Case Scenario

The Low case Scenario stipulates that the level of poverty increases countrywide. The percentage of low-income households increases gradually from 32% to 45 %. That is from the base year (1999) to 2025. The total energy demand for the sector will increase from 62.5 PJ to 188.14 PJ. The increase in the total energy demand is due to the increasing number of poor households. The percentage of households that use three-stone stoves for firewood decrease from 88 % to 80 %. The rest of the households use agricultural wastes. The use of woodfuel increases from 54.2 PJ to 149.07 PJ. Agricultural waste accounts for 20 % of the total household energy need. The use of kerosene for lighting is 0.36 PJ.

Medium Income Household

Status Quo Scenario

If consideration is taken of the status quo scenario, medium income households will have access to more sources of fuel for cooking than low-income households. The percentage of middle-income households' that have access to sources of fuel for cooking and lighting increases from 48.2 % to 50 %. The energy demand in this sector increase from 102.5 PJ to 232.3 PJ .

Most of the households depend on wood fuel for cooking. The composition of energy mix is 93 % fuel wood, 4.3 % agricultural waste and 1.9 % charcoal. The percentage of households using charcoal is 8 %. Although kerosene is mostly used for lighting, 6% of the households use it for cooking. Kerosene used for cooking and lighting is 1.9PJ.

Enhanced Scenario

The enhanced scenario assumes that the medium rural household income would improve. It was assumed that the percentage of this category of household would increase from 48.2 % to 60 % that is, from 1999-the base year, to 2025. The total energy demand increases from 102.8 PJ to 242.3 PJ. The use of wood fuel increases from 93.5 PJ to

227.6 PJ. The increment is a result of improved income. The use of agricultural wastes is 2.6 %. The use of kerosene for cooking and lighting is 2.7 PJ.

Low Case Scenario

The Low case Scenario presumes that due to the prevailing poverty, the percentage of medium rural households decreases from 48.2 to 45 %. The total energy demand increases from 102.8 PJ to 179 PJ. The use of wood fuel reaches 163.6 PJ in the year 2025. It is assumed that 90% of the households would rely on three-stone stove for cooking. The use of kerosene for cooking and lighting is 1.5 PJ. The use of agricultural waste is 6.25% of the total energy demand.

High Income Household

Status Quo Scenario

This class of households can afford to use different sources of energy for cooking and lighting. Taking consideration of the status quo scenario, the percentage of high-income households increases from 19.2 % to 25 %. That is from the base year-1999, to 2025. The energy demand in this sector increases from 40.6 PJ to 114.59 PJ in 2025. There is a high increase in the energy demand because of the increase in the number of high-income households. The availability of grid electricity is still very low.

The percentage of households using charcoal increase from the present 8% to 10% and the percentage using kerosene for cooking reaches 10% . Wood fuel contributes 97.1 % of the total energy need and charcoal contributes 2.4 %. The rest use commercial fuels.

Though however none of the households was using LPG in the base year, it was assumed that by 2025, 1% of the households use LPG for cooking , consuming 0.06 PJ. Kerosene consumption is 2.24 PJ. Most of the households depend on kerosene as the main source of fuel for lighting.

Enhanced Scenario
Taking consideration of the enhanced scenario, the number of high-income households increase from 19.2% to 35 %. Charcoal is used by 15 % of the households. Households using LPG increase to 2%.

The total energy demand increase from 40.6 PJ to 107.7 PJ. That is from 1999 to 2025. Firewood constitutes 92.5 % of the household energy need, while charcoal's contribution is 3.8 % and the rest of the energy comes from other sources like petroleum products. LPG consumption reaches 0.05 PJ.

Low Case Scenario
The Low case Scenario depicts a decrease in the number of high-income households, from 19.2 to 15 %. Charcoal is used by 7 % of the households. Use of LPG reaches 1% of the total number of all the households.

The total energy demand increases from 40.6 PJ to 68.21 PJ. Firewood constitutes 96 % of the household energy need, while charcoal contribution is 1.7 % and the rest use other sources like petroleum products. LPG consumption reaches 0.1 PJ by the year 2025. The high dependence on fuel wood is due to limited availability of low cost alternative fuel.

7.5.1.2 Urban Households

Energy consumption rises faster in urban areas than in rural areas because the rate of immigration from the rural to urban centres is higher than population growth in the rural areas. There is high dependence on charcoal in the urban household. Urban households have more access to modern sources of energy like electricity and LPG. The use of LPG is limited to high-income households. The cost of LPG appliances and lack of effective promotion has lead to low consumption in households.

Taking consideration of the Status Quo Scenario, the energy demand increases from 20.4 PJ to 61.7 PJ. The Low Case Scenario presumes that energy demand reaches 57.8 PJ by the year 2025. The Enhanced Scenario shows that the projected energy demand is 86.8 PJ. The trend of energy demand in urban households is as illustrated in Figure 7.8.

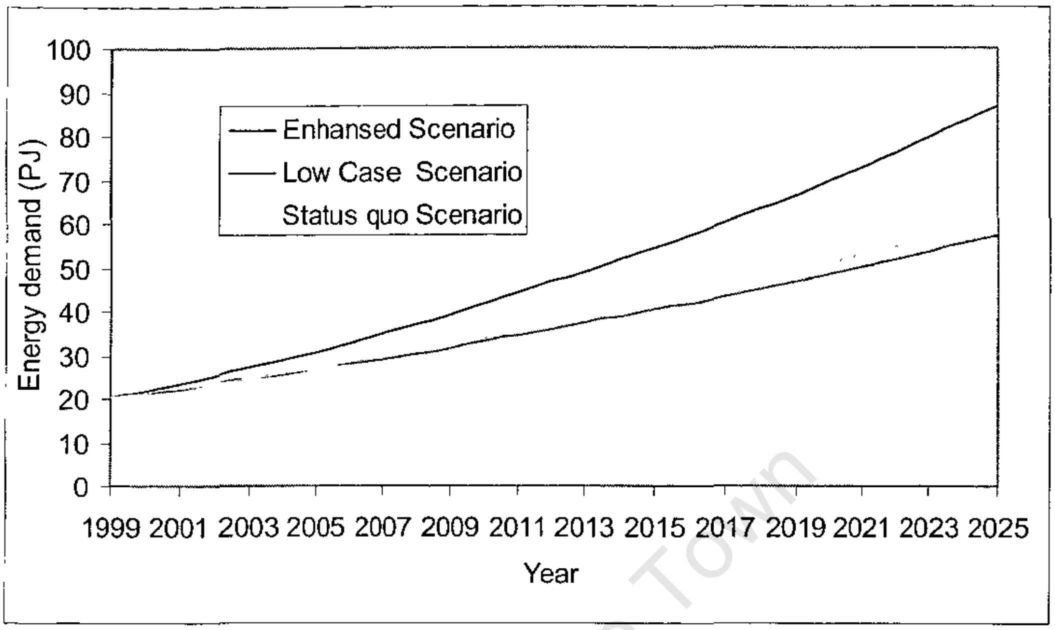


Figure 7.8 : Trend of urban household energy demand (1999-2025)

There increment in energy demand is highest in the Enhanced Scenario, because it was assumed that with increasing national GDP, there would be rapid migration from rural to urban areas. The demand for charcoal increases tremendously.

Energy Mix for Urban Household

The energy mix for urban household is shown in Table 7.14. The use of commercial fuel continues to be the main source of energy in urban household. Wood fuel and agricultural waste are considered as non commercial energy sources.

Table 7.14 : The percentage contribution of commercial energy in urban household

	SCENARIOS		
Fuel sources	Status quo (%)	Enhanced (%)	Low Case (%)
Wood fuel	10.5	10.0	14.9
Agricultural waste	0.7	0.6	1.6
Commercial fuel	88.8	89.4	83.5
Total			

Low-income household depend on firewood and charcoal with limited use of agricultural wastes for cooking. The urban households have limited access to modern energy apart from kerosene which they use for lighting.

Status Quo Scenario

Most of the urban household depend on woodfuel, charcoal and to a lesser extent agricultural wastes for cooking. The percentage of low-income households decrease gradually from 12% to 10%, that is from 199 to 2025. The total energy demand for the sector increases from 2.26 PJ to 4.5 PJ. The demand for charcoal and firewood reaches 3.34 PJ and 1 PJ respectively.

Enhanced Scenario

Basing on the enhanced scenario, incomes are expected to improve among the low-income urban households. The percentage of low-income households gradually decrease from the 12% to 5%. The total energy demand for the sector increase from 2.26 PJ to 3.34 PJ; that is from the base year (1999) to 2025. The contribution of charcoal and woodfuel is 73.8 % and 22.5 %, of the total energy needs respectively. The low energy demand is due to decrease in the number of low-income households over time.

Low Case Scenario

In this scenario, the level of poverty increases countrywide. The percentage of low-income households increase from 12% to 20 %, that is from 1999-the base year to 2025. There is larger urban poor households than there was in the base year. The total energy demand for the sector increases from 2.26 PJ to 8.22 PJ; that is from 1999-the base year to 2025. The increase in energy demand is due to the increasing number of poor households.

Medium Households

Status quo Scenario

Basing on the status quo scenario, it was forecasted that there would be gradual improvement of the household and the percentage of this category of households' decrease from 38 % to 35 %. That is from 1999-the base year to 2025. The energy demand increases from 7.1 PJ to 18.48 PJ. The percentage of households using metallic stoves is 75% and 20% of the households use improved stoves. Wood fuel is estimated to constitute 12 % of the total energy demand.

Enhanced Scenario

Under this scenario, there is reasonably higher income per households, higher than in the other two scenarios. The percentage of medium households decreases from 38% to 30 %. The energy demand in this sector increases from 7.1 PJ to 22.84 PJ. Charcoal and firewood contribution is 76 % and 10.5 % respectively and the rest of the energy demand is for other sources like kerosene.

Low Case Scenario

Under this scenario, there is normal urban migration. The energy demand increases from 7.1 PJ to 18.58 PJ. The percentage of this class of household would increase from 38 % to 50 %. The charcoal and firewood consumption is 14.1 PJ and 2.1 PJ respectively.

High Income Households

In this scenario, it is assumed that the percentage of high-income household is highest in the urban areas and that the percentages of low-income households would be least. The use of commercial energy like LPG and electricity is the highest while the dependency on biomass is reduced significantly.

Status quo Scenario

Basing on this scenario households can afford to use different sources of energy for cooking and lighting. The percentage of high-income households increases from 50 % to 55 %. The energy demand increases from 11 PJ 38.5 PJ. This is from 1999-the base year to 2025. The use of improved stoves increases from 16% to 20%. It is assumed that 5% of the households would use LPG for cooking. The rest of the households would rely mostly on three-stone stoves and electricity for cooking.

Enhanced Scenario

This scenario is the most favourable; the percentage of high-income households increases from 50 % to 65% by the year 2025. The total energy demand increases from 11 PJ to 60.5 PJ in 2025. The use of improved stoves increases from 16% to 40 % in 2025. The use of metallic charcoal stoves reduces from 80% to 30%. The percentage of households that use LPG for cooking reaches 10%. The rest of the households rely mostly on three-stone stoves and electricity for cooking. The use of biomass and commercial fuel constitutes 76.7 % and 23.3% of the total household energy demand respectively.

Low Case Scenario

The percentage of the households in this category increases from 38% to 50%. It is assumed that 80% of the households would use metallic charcoal stoves. The use of improved stoves and LPG for cooking is 15% and 7% respectively. The energy demand would increase from11 PJ to 30.8 PJ by the year 2025. Biomass energy would contribute 81% of the household energy need while commercial fuel covers the rest.

The Energy Mix for Household Sector

Household is the largest consumer of energy. The energy mix for 2025 is shown in Table 7.15.

Table 7.15 : Energy mix in household sector in percentage

	Scenarios		
Fuel	Status quo	Enhanced	Low Case
Agric Waste	5.1	2.7	10.2
Charcoal	9.8	14.3	8.9
Electricity	1.7	2.4	1.2
Kerosene	1.3	1.9	1.1
LPG	0.1	0.3	0.1
Fuel wood	82.0	78.4	78.5

The energy mix for household sector is dominated by wood fuel which accounts for about 80% of the household energy demand. There is increasing use of charcoal in the Enhanced Scenario. The use of charcoal has two effects the first being that the conversion efficiency during its production is low and the efficiency of the charcoal stoves is also low. Furthermore charcoal combustion produces carbon monoxide that is harmful.

The great challenge is to increase the share of electricity and LPG use mostly in urban household. One of the solutions can be increasing access to cheap and affordable electricity and introduction of a favourable policy like subsidies for specific fuels and its promotions such as LPG.

7.6 Projected Energy Demand in Industrial Sector

Uganda has experienced high industrial development over the last decade. It is expected that there will be a high increment in energy demand in this sector. The energy sources of interest in the industrial sector are biomass, electricity, and petroleum. This sector covers both small-scale and large-scale industry sub-sectors. Although Uganda has a low rate of industrialisation there are opportunities for expansion if there was cheap and reliable energy.

Changes in future energy demand were assumed to follow changes in key driving economic parameters. The micro economic data used for forecasting in this study are; value added in industry, value added in agriculture and the construction sector contribution to the GDP.

For the industrial sector, the demand was assumed to increase in proportion to growth in industry value added. The data for industry value added for different scenarios are as shown in Table 7.16. For those industries, which are agro-based, like tea and sugar, the data used for projection is based on the value added in agriculture, as illustrated in Table 7.17. There are other products that are used in the construction industry (like bricks and lime). In this case the projected energy demand was based on the percentage increase of the contribution of the construction sector to GDP. The main parameters are as shown in Table 7.18. The data for fuel oil was aggregated and the projections were based on industry value added.

Table 7.16 : Industry value added percentage change (1999-2025)

Scenarios	1999-2005	2006-2010	2011-2015	2016-2020	2021-2025
Status quo	11	12	8	7.5	7.5
Low Case	10	8	7	6	5
Enhanced	13	14	10	9	9

Table 7.17 : Agriculture value added percentage change (1999-2025)

Scenarios	1999-2005	2006-2010	2011-2015	2016-2020	2021-2025
Status quo	3.5	3.5	3.5	3	3
Low Case	3	2.5	2.5	2	2
Enhanced	4	4.5	4.5	4	4

Table 7.18 : Contribution of construction sector to GDP in percentage (1999-2025)

Scenarios	1999-2005	2006-2010	2011-2015	2016-2020	2021-2025
Status quo	8	7	6	5.5	5
Low Case	7	6	5	4	4
Enhanced	9	8	7.5	7	7

Electricity

Electricity is the most important source of energy in the industrial sector. Demand for electric energy for industrial use is higher than supply. As a result some industries resort to the use of generators during load shedding hours. The industrial energy demand for the base year is estimated as shown in Table 7.19.

Table 7.19: Electric energy demand in the industrial sector

Components of energy demand	Energy demand (PJ)
Energy consumption from grid	0.586
Suppressed demand (derived from load shedding)	0.138
Private generators	0.036
Non technical losses	0.029
Total energy demand	0.789

The electric energy demand in 1999 (the base year) was 0.789 PJ. The electricity demand in the industrial sector was expected to increase as the country continues to develop. Further envisaged was that the availability of sufficient electricity and other utilities would accelerate industrial development. The trends of electric energy demand in the industrial sector for the three scenarios are as shown in Figure 7.9.

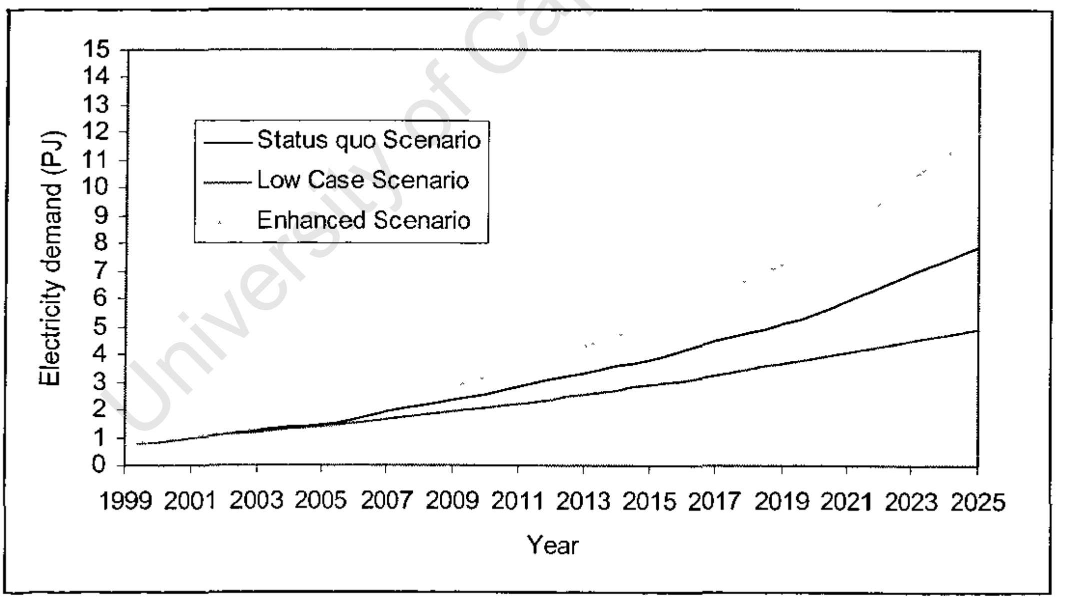


Figure 7.9: Electricity demand in the industrial sector

In the Status quo Scenario, it was assumed that there was a moderate increase in industrial development. The electricity demand would increase from 0.79 PJ to 7.85 PJ. In the Enhanced Scenario, there would be a high rate of industrialisation. In this case electric energy demand would reach 12.01 PJ. In the Low Case it was forecasted that the economy would perform poorly, which could lead to a low industrial energy demand. In this case, the electricity demand would be 4.9 PJ.

Total Energy Demand in the Industrial Sector

In the Status Quo Scenario, the energy demand in the industrial sector would increase from 13.7 PJ to 60.7 PJ. That is from 1999-the base year to 2025. In the Enhanced Scenario the energy demand would reach 84.6 PJ and in the Low Case Scenario it would be 45 PJ. In general energy demand would increase between three and six fold over the next two decades. The trend of industrial energy demand forecast is as illustrated in Figure 7.10.

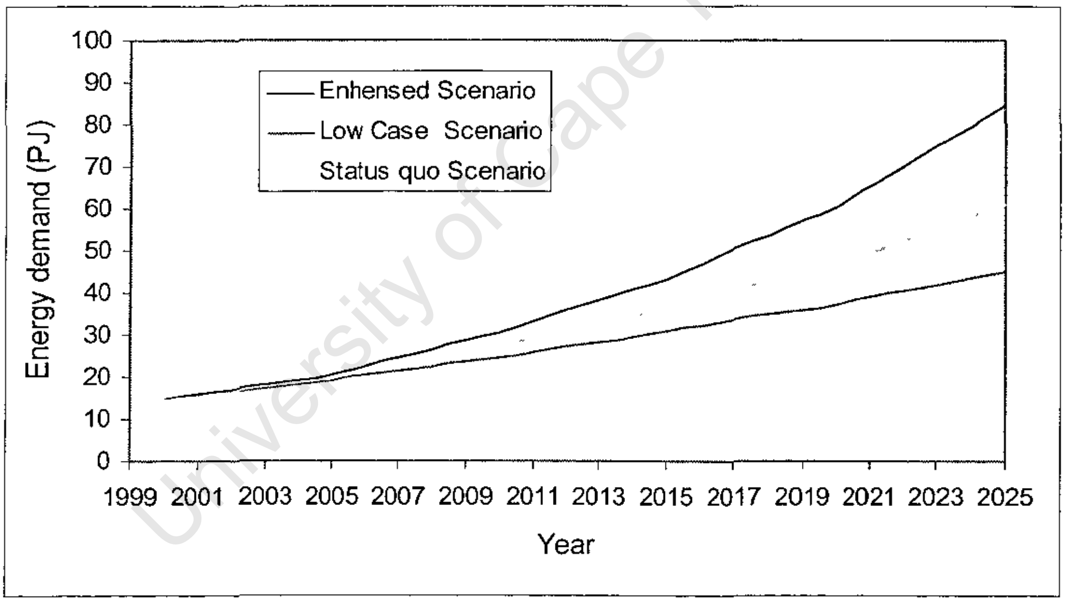


Figure 7.10: Trends of industrial energy demand forecast (1999-2025)

In the Status Quo Scenario, the energy mix for industrial applications is as given in Figure 7.11.

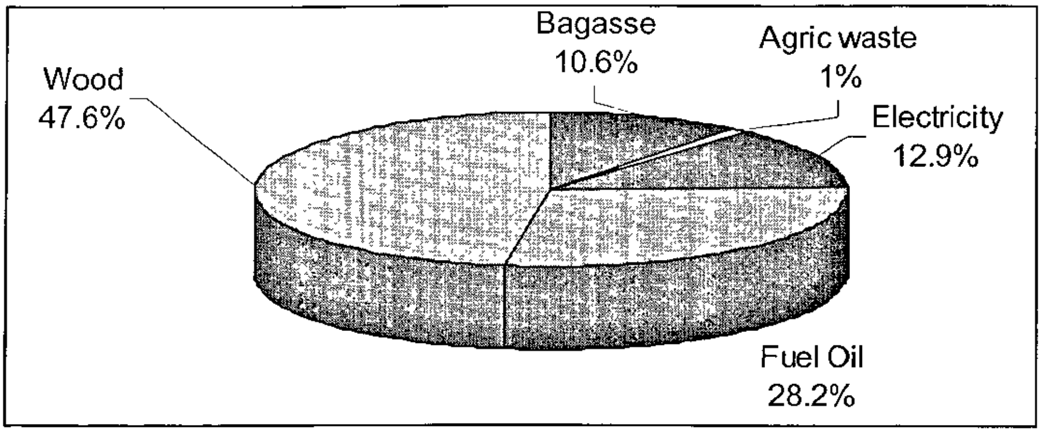


Figure 7.11: Energy mix Status quo Scenario 2025

Biomass was the leading source of energy for industrial applications. Commercial energy demand is 41.1 % of the total energy need. Bagasse is utilised for steam and electricity generation in the sugar industry. Coffee husks are expected to find application in brick production and other thermal processes. In the most favourable scenario, the projected energy demand mix is as illustrated in Figure 7.12.

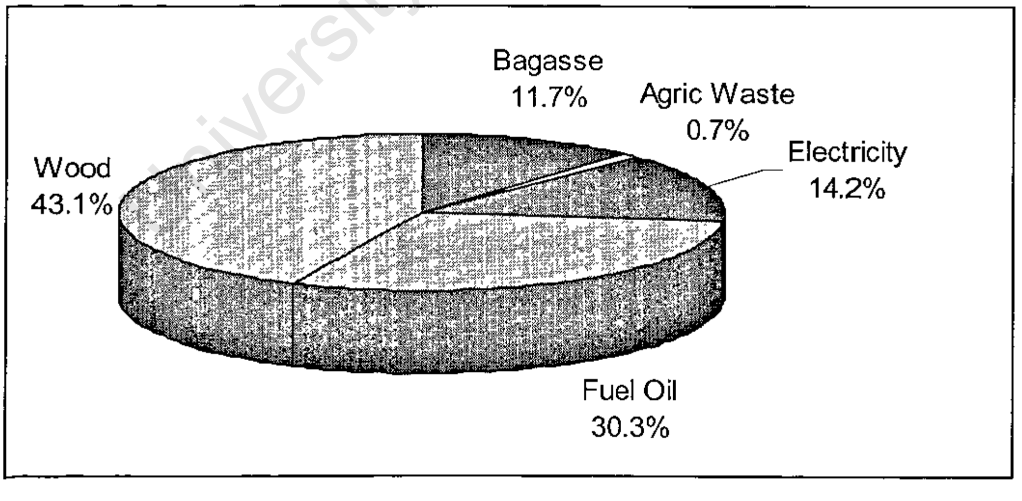


Figure 7.12 : Enhanced Scenario projected energy mix in 2025.

In the Enhanced Scenario, commercial energy would constitute about 44.5 % of the total industrial energy demand. In the Low Case Scenario, the projected energy demand mix, biomass constitutes 65.5% of the total energy demand as shown in Figure 7.13.

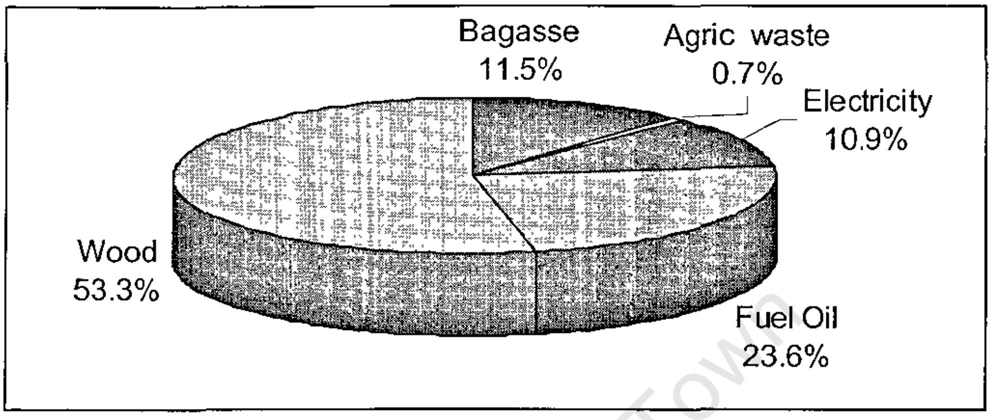


Figure 7.13 : Low Case Scenario energy mix in 2025

There would be high dependency on fuel wood followed by fuel oil. Electricity is important source of energy as prime mover of industrial equipment. In this scenario there wuold be limited development in electricity sub sector.

7.6.1 Large Scale Industries

Large-scale industries mostly use electricity and oil fuel. Oil fuel is used mostly for steam generation. Basing on the Status Quo Scenario, it is forecasted that in the agro-based products, like tea and sugar, the energy demand would be proportional to the agriculture value added. The small-scale industries considered in the modelling are the industries that rely on biomass. In the Status quo Scenario, the energy demand in the industrial sector would increase from 7.1 to 35.45 PJ. In the Low Case Scenario, the energy demand would reach 24.34, while in the most desirable scenario; the projected energy demand would be 51.58 PJ. The energy demand forecast for the three scenarios are shown in Figure 7.14.

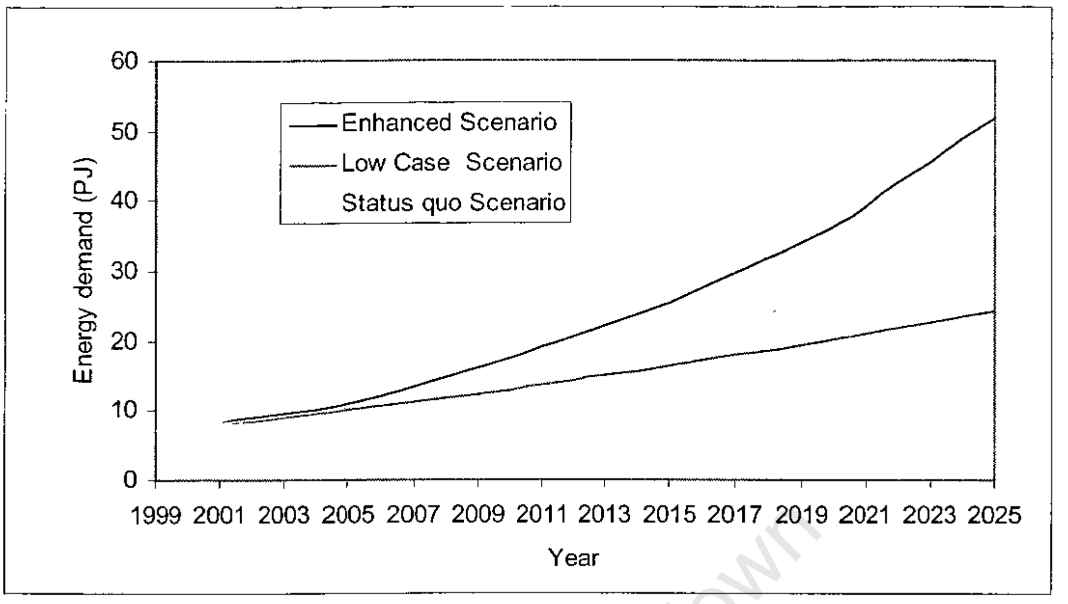


Figure 7.14 : Energy demand in large scale industries projections for the three scenario (1999-2025)

The energy mix for large-scale industries for the three scenarios is as illustrated in Table 7.20.

Table 7.20 : Energy mix in large industrial sector in percentage

	Scenarios		
Fuel	Status quo	Enhanced	Low Case
Bagasse	17.5	18.6	16.5
Agric. Waste	1.1	1.1	1.2
Electricity	22.1	23.2	20.1
Fuel oil	48.3	49.4	43.7
Wood	10.9	7.7	18.4
Total	100	100	100

As the Table 7.20, commercial energy accounts for over 64 % of the total energy need in large industries. It is imperative to note that for Uganda to develop, there is a need to provide commercial energy at low cost mostly to the large-scale industries. It is the provision of commercial energy, development of infrastructure; favourable investment policy and stable government that are among the prerequisites for large-scale industrial development.

Sugar Industry

The future energy demand in this sector is proportional to value added in agriculture. There is energy waste in the sugar factories and room for improvement in this sector by installing more efficient boilers. The electric energy consumption in the base year was 0.122 PJ. The projected electric energy demand is aggregated within industrial sector.

Basing on the Status quo Scenario, biomass energy consumption in this sector would increase from 2.7 PJ to 6.2 PJ. In the Low Case Scenario, biomass energy demand reaches 5 PJ by the year 2025. If more efficient boilers were to be installed and the sugar factories were able to sell excess power to the grid, the biomass energy intensity would decrease from the present 21.1 GJ to 16.37 GJ per tonne; that is from 1999 to 2025. In the Enhanced Scenario, the total biomass energy demand would reach 9 PJ by 2025.

Tea Industry

The tea industry is one of the leading woodfuel energy consuming sectors in Uganda. Investors in tea industries grow most of the wood they need. The future energy demand in this sector is proportional to value added in agriculture. Most of these tea factories were rehabilitated in the middle of 1990's. The biomass energy consumption is 1.88 PJ. The projected electric energy demand is aggregated within the industrial sector.

In the Status quo Scenario, the biomass energy demand would increase from 1.88 PJ to 3.86 PJ, while in the Enhanced Scenario; biomass energy demand would be 4 PJ. In the Low Case Scenario biomass energy demand would be 3.5 PJ by the year 2025.

Bricks and Tiles

There are four main medium-scale factories in Uganda that produce brick and tiles using machines. They rely on coffee husks for thermal applications. The micro economic data used for forecasting in this sector is the rate of increase of the construction sector contribution to GDP.

In the Status quo Scenario, biomass energy demand would increase from 0.077 PJ to 0.4 PJ, while in the Low Case Scenario; the biomass energy demand would be 0.3 PJ by 2025. In the Enhanced Scenario the biomass energy demand would reach 0.56 PJ by the year 2025.

7.6.2 Small-Scale Industries

Small-scale industries generally rely on biomass as the main source of energy. The small-scale industries considered are lime, bricks, fish smoking, tobacco and jaggery.

Changes in future energy demand in biomass-based small-scale industry were assumed to follow changes in key driving economic parameters. The micro economic data used for forecasting in this case are value added in agriculture and the construction sector contribution to GDP. The definition of value added is sum of gross out put less the value of intermediate inputs used in production

In the Status quo Scenario, total biomass energy demand will increase from 6.3 PJ to 25.27 PJ by the year 2025. In the Enhanced Scenario, the total biomass energy demand would be 32.71 PJ in 2025. In the low case Scenario, the energy demand would be 20.65 PJ by the year 2025. The trend of energy demand forecast is as shown in Figure 7.15.

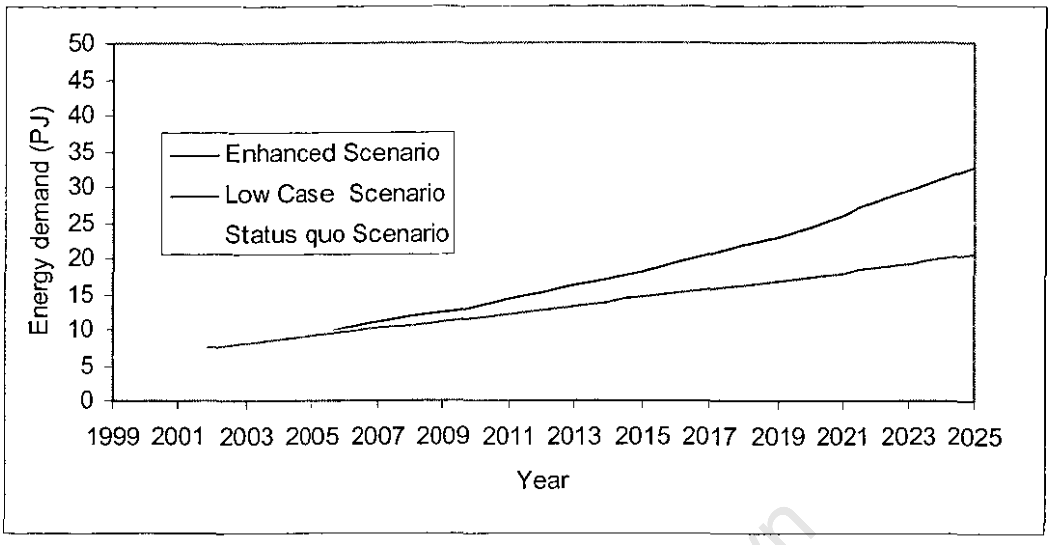


Figure 7.15: Trend in energy demand forecast in small -scale industries (1999-2025)

Lime Industry

The micro economic data used for forecasting in this case is the percentage rate of increase of construction sector contribution to GDP. The lime industry has large potential for improvement. When using traditional lime kilns, the energy intensity is 32 GJ per tonne while with improved lime kilns, the energy intensity is 16 GJ per tonne.

In the Status quo Scenario, total biomass energy demand would increase from 3.18 PJ to 14.7PJ by the year 2025. In this Scenario it was assumed that 90% of the kilns would be traditional type and the rest would be improved lime kilns. In the Enhanced Scenario, it was assumed that 75% would be of the traditional type and the rest would be improved lime kilns. The total biomass energy demand would be 20 PJ in 2025. In the low case Scenario, it was assumed that 95% of the kilns would be of traditional type and only 5% would be improved kilns. The biomass energy demand would be 11.5 PJ by the year 2025.

Tobacco

Tobacco industries rely on firewood for curing. New designs of barns have been introduced countrywide over the last five years. The micro economic data used for forecast in this case are value added in agriculture.

In the Status quo Scenario, it was assumed that Malakisi barns would be phased out by 2015. The biomass energy demand would increase from 1.07 PJ to 2.0 PJ by 2025. In Low Case Scenario, 95% of the barns could be improved while 5% would be traditional kilns. The energy demand would be 1.69 PJ in 2025. In the Enhanced Scenario, it was assumed that there would be rapid phase out of traditional barns. In 2010 improved barns would replace all traditional barns. The energy consumption would reach 2.49 PJ by the year 2025.

Fish Smoking

Fish smoking is practised using firewood. There are two main types of fish smoking, open fire and closed fire. Closed fire fish smoking is slow but it is more efficient than open fire. There is growing market for both fresh fish for export overseas and dried fish for export to the neighbouring countries. The micro economic data used for forecasting in this case is value added in agriculture.

In the Status quo Scenario, it was assumed that the use of open fire smoking would reduce from 70% to 60% by the year 2025. The energy demand in this case would rise from 0.59 PJ to 1.26 PJ by the year 2025. In the Low Case Scenario it was assumed that 70 % of fish smoking would use open fires. The energy demand would be 1.11 PJ. In the Enhanced Scenario, it was assumed that 50% of fish smoking would use open fires while the rest would use closed fire smoking. The energy demand in this case would reach 1.43 PJ by the year 2025.

Jaggery

The jaggery industry is common among the sugar cane out growers. They rely on bagasse and firewood for thermal processing of the jaggery. The micro economic data used for forecast in this case are value added in agriculture.

In the Status quo Scenario, total biomass energy demand would increase from 0.59 PJ to 1.38 PJ by the year 2025. In the Enhanced Scenario, the total biomass energy demand would be 1.71 PJ in 2025. In the low case Scenario, the biomass energy demand would be 1.11 PJ by the year 2025.

Brick Making

Brick making is one of the fastest growing small-scale industries in the rural areas. The present brick kilns have a high-energy intensity. It is possible to reduce the energy intensity by improving the design of the kilns. The micro economic data used for forecasting in this sector is the percentage rate of construction sector contribution to GDP.

In the Status quo Scenario, it was assumed that the energy intensity would be reduced from 2.34 GJ per tonne to 2.268 GJ per tonne in rural small-scale industries. In the urban areas, the energy intensity would be reduced to 2.1096 GJ per tonne in 2025. The projected energy demand would be 18.8 PJ.

In the Enhanced Scenario, it was assumed the energy intensity would be reduced from 2.34 GJ per tonne to 2.109 GJ per tonne in rural small-scale industries. In the urban areas, the energy intensity would be reduced to 1.872 GJ per tonne by the year 2025. The projected energy demand would reach 24.6 PJ.

In the Low Case Scenario, it was assumed that the energy intensity would remain constant at 3.24 GJ per tonne. The projected energy demand would be 15.4 PJ by the year 2025.

7.7 Commercial Sector

The commercial sector is a fast growing sector. It covers section sub-sectors like hotels and restaurants, bakeries, breweries and distilleries and institutions. The drivers of energy demand in this sector are the population growth, increase in enrolment in institutions, contribution of sector to GDP and GDP monetary growth rates.

Electricity

Electric energy is one of the most important energy sources in the commercial sector. In this study street lighting is included in the commercial sector. Electricity demand in the commercial sector was reworked to reflect the differences between energy demand and supply. The components of total energy demand are as shown in Table 7.21.

Table 7.21: Energy demand in the commercial sector

Components of energy demand	Energy demand (PJ)
Energy consumption	0.395
Suppressed demand(derived from load shedding)	0.015
Private generator	0.023
Non technical losses	0.02
Total energy demand	0.453

The electric energy demand in the commercial sector was 0.453 PJ in 1999-the base year. The projected electric energy demand was based on the percentage increase of the monitory GDP. Although the average increase in the monetary GDP over the last decade was 8.0% per annum, the lowest attained growth rate of 5.7% was in 1999 and the highest was 12 % in 1994. The projected increase in monetary GDP used in forecasting electric energy demand in the commercial sector is as shown in Table 7.22.

Table 7.22 : Projected annul percentage growth rates in monetary GDP

Scenarios	1999-2005	2006-2010	2011-2015	2016-2020	2021-2025
Status quo	7.5	7.5	7.5	6.1	6.1
Low Case	6.1	5	4	3.8	3.5
Enhanced	7.9	8.2	10.5	10	8.5

The electric energy forecast in the commercial sector is as shown in Figure 7.16.

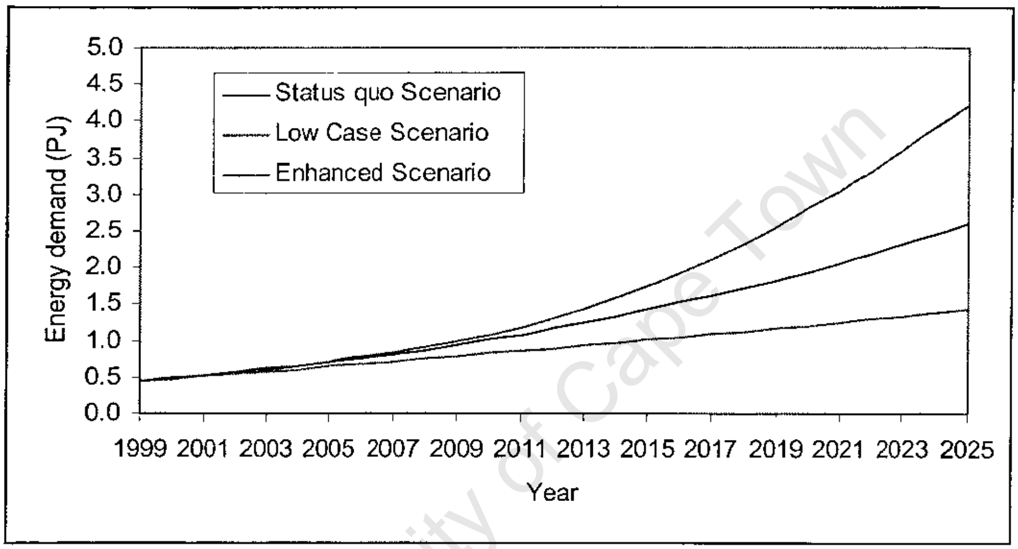


Figure 7.16: Electric energy demand forecast in the commercial sector

In the Status quo Scenario it is assumed that improved commercial activities would take place as the result of economic stabilisation. In this case electric energy demand in the commercial sector would increase from 0.453 PJ to 2.61 PJ by the year 2025. In the Enhanced Scenario demand for electricity would be the highest due to improved performance of the economy. Consequently, energy demand would reach 4.22 PJ and in Low Case Scenario it would be 1.44 PJ by the year 2025.

Total energy demand in the commercial sector.

In the Status quo Scenario, the total energy demand increases from 21.4 PJ to 63.0 PJ by the year 2025. In the Enhanced Scenario, the projected energy demand would reach 86.6

PJ while in the Low Case Scenario the energy demand would be 52.7 PJ. The trends of energy demand in the commercial sector are as shown in Figure 7.17.

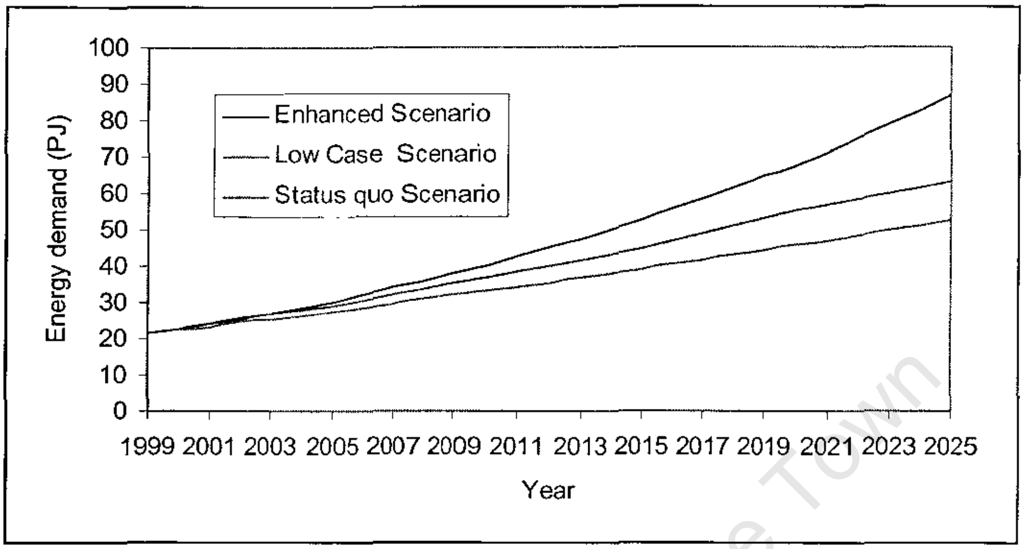


Figure 7.17: Projected energy demand in commercial sector

The major energy sources, used in the commercial sector are charcoal, wood fuel, LPG and electricity. The energy mix for the three scenarios by the year 2025 is as illustrated in Table 7.23.

Table 7.23: Energy mix in percentage for the commercial sector in 2025

	Scenarios		
Fuel	Status quo	Enhanced	Low Case
Firewood	70.6	61.0	69.6
Charcoal	22.9	30.1	24.5
LPG	2.4	3.9	1.3
Electricity	4.1	5.0	4.6
Total	100	100	100

In all three scenarios, biomass would be the dominant energy source in the commercial sector, while commercial fuel would account for less than 9 % of the total energy needs.

Hotels and Restaurants

The number of the hotels would increase, as there would likely be an increase in tourism and business travel. The hotels sector contribution to the GDP would also increase. Large hotels mostly rely on the clean fuels like electricity and LPG for cooking and lighting. The use of charcoal is limited to medium and small size hotels. The growth rate is assumed to be proportional to the industrial growth rates, because as the numbers of industries grow more people would be able to dine out. As a result, this sector would get a boost due to industrialisation. The micro-economic parameter used in the energy demand projection was based on industry value added. The electric energy demand was aggregated under the commercial sector.

In the Status quo Scenario, the biomass energy demand would increase from 7.2 PJ to 30.6 PJ in 2025. The use of LPG in this sector would increase from 0.1 PJ to 1.5 PJ over the same period. In the Enhanced Scenario the energy demand would reach 43.9 PJ, while in the Low Case Scenario, the energy demand would be 29.3 PJ.

LPG would gradually substitute the use of biomass. In the Status quo Scenario the number of hotels and restaurants using LPG would increase from 10% to 20 %. In the Enhanced Scenario, use of LPG would reach 30%, delivering 3.36 PJ of energy for cooking.

Large Hotels

In the Status quo Scenario, the energy demand for large hotels would increase from 0.9 PJ to 6.7 PJ in 2025. In the Low Case Scenario, the energy demand would be 5.3 PJ while in the Enhanced Scenario the energy demand would reach 12.1 PJ by the year 2025.

Small restaurants

Small restaurants are very common in all trading centres. They rely mostly on charcoal and firewood. The use of modern forms of energy is negligible. The projected energy demand in this sector is assumed proportional to the rate of urbanisation. The rate of urbanisation for the three scenarios is as shown in Table 7.24.

Table 7.24: The growth rate of urbanisation in percentage.

Scenarios	1999-2005	2006-2010	2011-2015	2016-2020	2021-2025
Status quo	5	5.5	5.5	4.5	4.5
Low Case	4.5	4.5	4.5	4	4
Enhanced	6.5	7.5	7	6.5	6.5

It is assumed that as woodfuel get scarce, most of the enterprises in this sector would use more charcoal than firewood. In the Status quo Scenario, the energy demand would increase from 6.2 PJ to 23.8 PJ and in the Low Case Scenario the energy demand would reach 18.6 PJ by the year 2025. In the Enhanced Scenario the energy demand would be 31.8 PJ.

Bakeries

The types of bakeries under consideration are the ones that use woodfuel for baking. Most of these bakeries are located in the peri-urban areas. The micro-economic parameter used in the energy demand projection was based on GDP growth rates.

In the Status quo Scenario, it was assumed that the energy intensity of the bakeries would reduce from 15 MJ per kilogram of bread to 13.5 MJ, and the energy demand would increase from 0.44 PJ to 1.48 PJ by 2025. In the Low Case Scenario, there would not be change in energy intensity. The energy demand would be 0.976 PJ by the year 2025. In the Enhanced Scenario, the energy intensity would reduce from 15 to 12 MJ per kilogram of bread and the total energy demand reaches 2.31 PJ by the year 2025

Breweries and Distilleries

Breweries and distilleries are the second largest consumer of biomass energy in the commercial sector. Most of these enterprises are found in the rural areas. The future energy need in this sector was assumed to be closely related to the rural population growth rates. The growth rate of energy consumption in this sub-sector is as shown in Table 7.25. It was assumed that as the economic situation improves, there would be a reduction in the consumption of locally made brews.

Table 7.25: The growth rate in percentage of energy demand in breweries and distilleries

Scenario	1999-2005	2006-2010	2011-2015	2016-2020	2021-2025
Status quo	3.3	2.5	2.5	2	2
Low Case	2	2	2	2	2
Enhanced	3.3	3	3	2.5	2.5

All the breweries and distilleries use open fires in processing the brew. It was assumed that the energy intensity would reduce from 45 GJ to 42.75 GJ in the rural areas, while in the urban areas the energy would be reduced from 67.5 GJ to 61.02 GJ by the year 2025. In the Status quo Scenario, the energy demand would increase from 8.9 PJ to 15.6 PJ by 2025. For the Low Case Scenario, it was assumed that there is no change in energy intensity. The energy demand would reach 15.1 PJ. In the Enhanced Scenario the energy demand would be 17.6 PJ.

Institutions

The institutions considered are schools, prisons, hospitals and tertiary institutions. The driving parameters used to project energy demand in this sector are the growth rates based on the last decade growth rates.

Schools

The schools were divided into two sections, primary and secondary schools. There has been a tremendous increase in enrolment in primary schools, since the government introduced free primary education. It implies that the number of secondary schools enrolments would also increase significantly in the next five years. From the energy perspective, schools which provide meals to pupils were considered. They are mainly boarding and day schools.

Primary Schools

The Government is implementing a programme that would provide free education for all primary pupils. At the beginning the enrolment rate is high but it would stabilise by the year 2005. The projected rates of increase in primary enrolment are as shown in Table 7.26.

Table 7.26 : Projected rate of increase in percentage in primary school's enrolment

Scenario	1999-2005	2006-2010	2011-2015	2016-2020	2021-2025
Status quo	5	4	3	2	2
Low Case	4	2	2	2	2
Enhanced	6	3	3	3	3

In the Status quo Scenario, the number of boarding primary schools would increase from 0.88 % to 1% of the total number of primary schools and the number of mixed schools would increase from 4.28 % to 6 % by the year 2025.

Secondary Schools

In most of the secondary schools, the projected rates of increase in enrolment are as shown in Table 7.14. The high increase is to cater for the expected increase in enrolment from primary schools. The projected rate of increase in secondary school's enrolment is as shown in Table 7.27.

Table 7.27: Projected rate of increase percentage in secondary school's enrolment

Scenarios	1999-2005	2006-2010	2011-2015	2016-2020	2021-2025
Status quo	11	9	6	4	3
Low Case	9	8	5	3	2
Enhanced	12	10	8	5	4

In the Status quo Scenario the forecast was based on the assumption that the percentage of boarding schools would reduce from 58.2 % to 35%, the rest would be day and mixed schools. In the Enhanced Scenario, the number of boarding schools would reduce from 58.1% to 40% by the year 2025. In the Low Case Scenario, the number of boarding schools would be 30% and the rest would be day and mixed schools.

The energy intensity in the boarding schools would decrease from 4.39 GJ per student to 3.951 GJ per student by the year 2025. In the Status quo Scenario, the energy demand in schools would increase from 3.6 PJ to 11.2 PJ in 2025. In the Enhanced Scenario, the projected energy demand would reach 16.9 PJ, and in the Low Case Scenario, the energy demand would be 8.6 PJ.

Prisons

The number of prisoners has increased from 11,475 in 1990 to 15,905 in 1999. The figure of 15,905 in the base year is more than double the prison capacity. All prisons are overcrowded. It is assumed that the government would find a solution to reduce the number of prisoner by facilitating and accelerating the court proceedings. In the Status quo Scenario, it is assumed that there would be low growth at 1.5 % per annum and in the Low Case Scenario it would be 1%. In the Enhanced Scenario, the growth rates would be 2 % per annum.

Nearly all the prisons use three stone stoves. They get their supply of firewood from their farms. The average energy intensity for cooking using three stone stoves was assumed to remain at 8.312 GJ per person. In the Status quo Scenario, the energy demand would increase from 0.132 PJ to 0.194 PJ by 2025. In the Low Case Scenario the energy demand would be 0.171 PJ while in the Enhanced Scenario, energy demand would reach 0.221 PJ by the year 2025.

Hospitals

There is a government effort to improve health services in general. There is also increasing number of private hospital to cater for increasing number of patients, The number of patients is expected to increase at rate of 1.5 % per annum in the Status quo Scenario while in the Low Case Scenario, the increment is 1% .In the Enhanced Scenario, the increase would be 2% per annum.

Most of the hospitals use both charcoal and firewood stoves simultaneously. In the Status quo Scenario, the use of three stone stoves would be 80%, while the rest use charcoal stoves and other appliances. The average energy intensity of cooking using charcoal stoves would decrease from 8.87 GJ to 7.83 GJ per patient per year. In this case, the total energy demand would increase from 0.33 PJ to 0.408 PJ in 2025.

In the Low Case Scenario, 5% of the hospitals use LPG stoves for cooking. The average energy intensity of cooking using three stone stoves and charcoal stoves is 8.87 and 10.403 GJ per person by the year 2025. The total energy demand would reach 394.1 TJ. In the Enhanced Scenario, LPG use for cooking would reach 15% and the use of firewood would be reduced to 70%. The average energy intensity of cooking using LPG stoves would be 0.24 GJ per person. The total energy demand would be 0.456 PJ in 2025.

Tertiary Institutions

The tertiary institutions considered are teachers' training colleges, technical schools and college of commerce. Most of these institutions have residence students. It is assumed that more institutions would be opened in future without boarding facilities. Most of them rely on biomass as the main source of energy for cooking. The use of LPG for cooking is still limited. Projected rates of increase in the tertiary institution enrolment are as shown in Table 7.28.

Table 7.28: Projected rate of increase in number tertiary institutions enrolment in percentage

Scenarios	1999-2005	2006-2010	2011-2015	2016-2020	2021-2025
Status quo	11	9	8	4	3
Low Case	10	8	5	3	2
Enhanced	12	10	8	5	4

The high increase in enrolment is expected up the year 2010. That would cater for the increasing number of students from the secondary schools. The number would stabilise at around 4% by the year 2020.

At present, the number of institutions that use LGP is negligible. In the Status quo Scenario, it was assumed that LPG would account for 10% of the energy and the energy intensity would be 0.11 GJ per student. The energy intensity of woodfuel in use would decrease from 6.075 GJ to 5.4677 GJ per student. In this scenario the energy demand would increase from 0.4 PJ in 1999-the base year to 0.94 PJ by 2025.

In the Low Case scenario, it was assumed that the percentage use of LPG would be 5%. The LPG would be used side by side with other fuels. Energy intensity of woodfuel would decrease from 6.075 GJ to 5.771 GJ per student. In this case, the energy demand would increase from 0.41 PJ to 1.08 PJ by the year 2025.

In the Enhanced Scenario, the use of LPG would contribute 15 % of the cooking and the rest would be woodfuel. It was assumed that the use of improved stoves would take root in schools. The energy intensity would be reduced from 6.075 GJ to 5.163 GJ per student. The energy intensity of LPG in use would reach 0.15 GJ per student in 2025. The total energy demand would reach 1.1 PJ by the year 2025.

Universities

There would be significant increases in the number of enrolments in the universities in the year 2010; the time when the students under the universal primary education would join the universities. The increase would not only be at the universities but also in other tertiary institutions. Most of these students would not be residing on campus. In 1999 (the base year) 13% of all students in tertiary institutions were in Universities.

There are new universities opening and the established universities are opening up campuses countrywide. In the Status quo Scenario, it is assumed that the percentage of students at universities would increase from 13% to 20% by the year 2025. In the Low Case Scenario; the percentage would increase to 15%. In the Enhanced Scenario, the percentage would reach 25% by the year 2025.

Most of these universities rely on woodfuel as the main source of energy for cooking. Makerere University has shifted from firewood to LPG for cooking. It is assumed that other institutions would follow suit. In the Status quo Scenario, the energy intensity of fuel wood would decrease from 3.82 GJ to 1.91GJ per student, while the use of LPG would increase from 0.22 GJ to 0.55 GJ per student by the year 2025. In this scenario energy demand would increase from 36 TJ to 94.8 TJ by 2025.

In the Low Case Scenario the energy intensity of woodfuel in use would decrease to 2.92 GJ and use of LPG would increase to 0.432 GJ per student. In this case, the energy demand increases from 36 TJ in 1999 (the base year) to 83.7 PJ by 2025. In the Enhanced Scenario all Universities would either use LPG or electricity for cooking. The energy intensity of LPG in use would increase from 0.22 GJ to 0.648 GJ per student. The total energy demand increases from 36 TJ to 43 TJ by the year 2025.

Electricity General

There are other uses of electricity, which is neither covered under commercial, nor industrial categories, as an example, electricity use in government buildings and education institutions. They are considered under general electricity. The electricity demand is higher than the supply. The components that built up the demand are as shown in Table 7.29.

Table 7.29: Energy demand in general sector

Components of energy demand	Energy demand (PJ)
Energy consumption	0.442
Suppressed demand (derived from load shedding)	0.030
Non technical losses	0.044
Total energy demand	0.516

The electricity demand in the general sector in the base year was 0.516PJ. The projected electric energy demand was based on the percentage increase of monetary GDP. The energy demand trends for the three scenarios from the base year to 2025 are as shown in Figure 7.18.

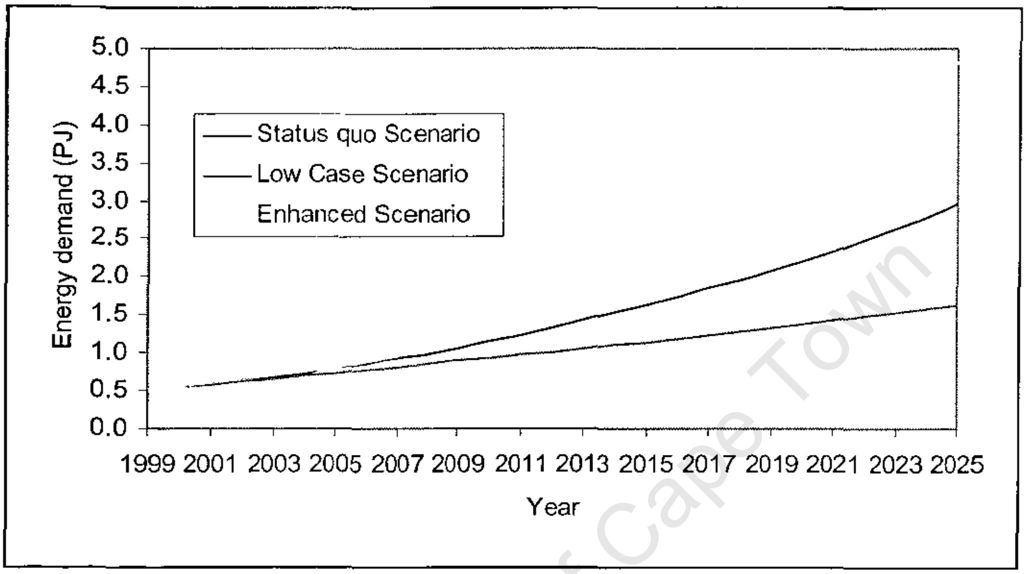


Figure 7.18 : Projected electric energy demand in the general sector.

In the Status quo Scenario, electric energy demand would increase from 0.453 PJ to 2.967 PJ by the year 2025. In the Enhanced Scenario the energy demand would be 4.818 PJ and in Low Case Scenario it would be 1.636 PJ by the year 2025.

7.8 Transport Sector

The transport sector is one of the fastest growing industries. In general energy demand projections assume that the energy consumption is determined by the level of economic development and by growth rates of the population. The forecast in the transport sector energy demand is driven by the increase in the number of passenger vehicle kilometres and the increase in the rate of passenger transport sub-sector contribution to GDP.

In the freight transport sub-sector the number of tonne-kilometres for goods and the GDP are the major driving parameters. The projected passenger vehicle kilometres and tonne-kilometres quantities were estimated by applying growth rates in population and GDP respectively.

There are many factors that contribute to the aviation fuel demand, including future investment prospects, tourism and national and regional security. Since all these factors have a direct link with GDP, air transport sub sector energy demand is assumed to be proportional to the growth rate of GDP.

In the Status quo Scenario, the energy demand in the transport sector would increase from 15.13 PJ to 68.23 PJ. In the Low case Scenario, the energy demand would be 44.4 PJ, while in the Enhanced Scenario; the energy demand would reach 93.36 PJ by the year 2025. The energy demand is shown in Figure 7.19.

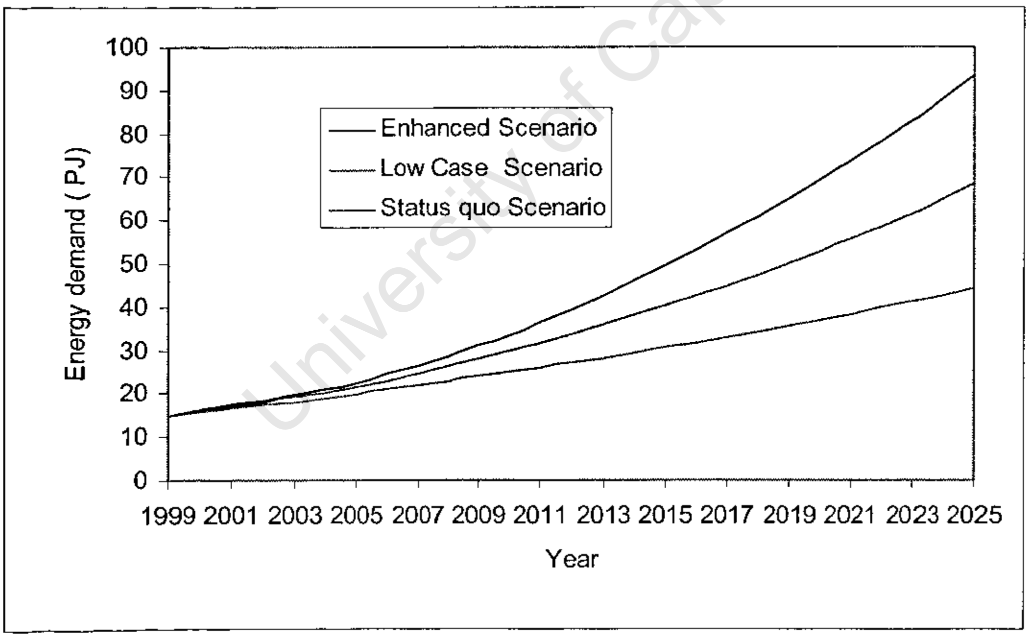


Figure 7.19 : Energy demand trend in transport sector (1999-2025).

The total energy demand in the transport sector in all three scenarios grows faster than GDP.

Passenger Travel

The population growth rate has the greatest impact on the future energy demand in the transport sector. The projected energy demand in this sector assumes that the population growth rates could be maintained at 3.4 % per annum. The amount of passenger travel (passenger-km/person) is expected to rise slightly more than the GDP increase. The GDP per capita increase in the base year was 5.5% per annum. The demand for road transport with respect to income elasticity for the three scenarios is as shown in Table 7.30.

Table 7.30 : Road Transport demand elasticity for the three scenarios

Scenarios	1999-2005	2006-2010	2011-2015	2016-2020	2021-2025
Status quo	1.11	1.10	1.10	1.00	1.00
Low Case	0.90	0.90	0.80	0.80	0.70
Enhanced	1.25	1.30	1.40	1.40	1.30

Minibuses are the most common means of travel in the urban and peri-urban areas. In the Status quo Scenario, it is assumed that the use of mass transport in the urban areas could start in the near future in order to reduce congestion within the City centre. That means that there would be a reduction in the number of minibuses. The percentage contribution of the small vehicles in passenger transport would reduce from 85.2% to 70% by 2025. There would be changes in the transport sector. The number of minibuses in the transport sector would reduce and the number of buses would increase. In 1999 (the base year), the number of passenger-km per person was 563. The contribution of the small vehicles and buses in passenger travel between the base year and 2025 is a shown in Table 7.31.

Table 7.31 : Contribution of small vehicles and buses in passenger travel (2025)

	1999	Scenario 2025		
Type of vehicles	Base year	Status quo	Low Case	Enhanced
Small vehicles (%)	85.2	75.0	80.0	70.0
Buses (%)	14.8	25.0	20.0	30.0

The types of commonly used means of transport and their projected contribution in passenger- kilometre per person by the year 2025 are as illustrated in Table 7.32.

Table 7.32: Contribution of passenger-km per person in 2025

Type of vehicle		Scenario in 2025		
Small vehicles	Base year (1999)	Status quo	Low Case	Enhanced
Minibus (Petrol)	44.2	30.0	40.0	20.0
Minibus (Diesel)	32.8	38.5	34.0	43.0
Cars	22.3	30.0	25.0	35.0
Motorcycles	0.7	1.5	1.0	2.0
Total	100	100	100	100

The number of small vehicles used in transport using petrol would decrease. In future, the fuel that would be dominant in the transport sector would be diesel. The energy demand in the transport sector for the three scenarios is as shown in Figure 7.20.

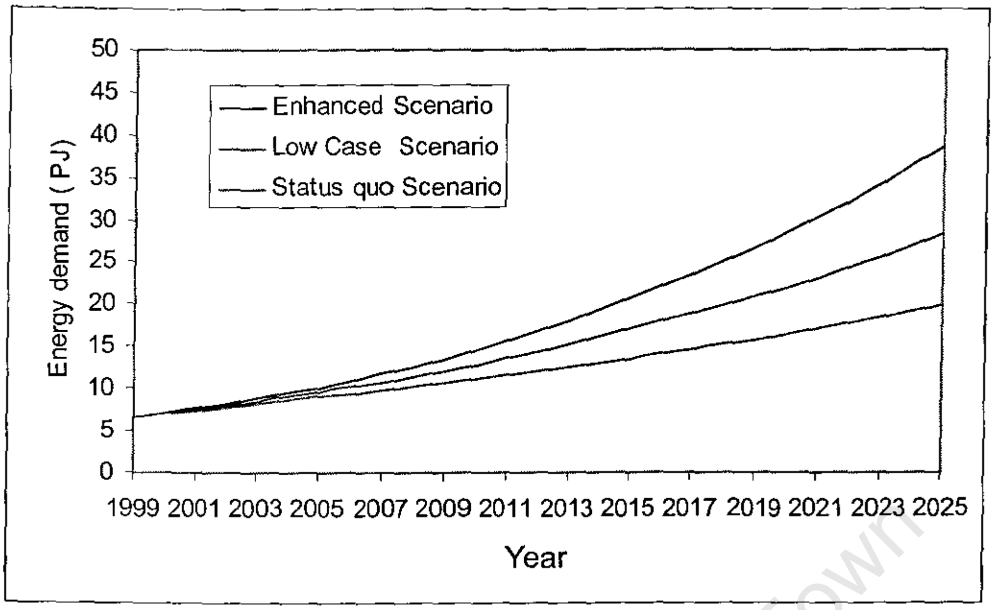


Figure 7.20: The projected energy demand in the passenger transport sector

In the Status quo Scenario, the energy demand in the passenger transport sector would increase from 6.64 PJ to 28.25 PJ by 2025. In the Low Case Scenario, the energy demand would be 19.81 PJ, while in the Enhanced Scenario; the energy demand could reach 38.65 PJ.

Freight Transport

Freight Transport was assumed to be linked to the population and GDP growth rates. It was assumed that as the economy improves, there would be more movement of merchandise. The demand for transport with respect to GDP elasticity for the three scenarios is as shown in Table 7.33.

Table 7.33: Freight demand elasticity for the three scenarios

Scenarios	1999-2005	2006-2010	2011-2015	2016-2020	2021-2025
Status quo	0.35	0.30	0.30	0.20	0.20
Low Case	0.30	0.25	0.25	0.15	0.15
Enhanced	0.35	0.40	0.45	0.40	0.40

In the Status quo Scenario, the energy demand in freight would increase from 6.78 PJ to 32.38 PJ in 2025. In the Low Case Scenario, the energy demand would be 20.58 PJ, while in the Enhanced Scenario, the energy demand could reach 43.2 PJ .The trend of energy demand in the freight transport sector is as shown in Figure 7.21.

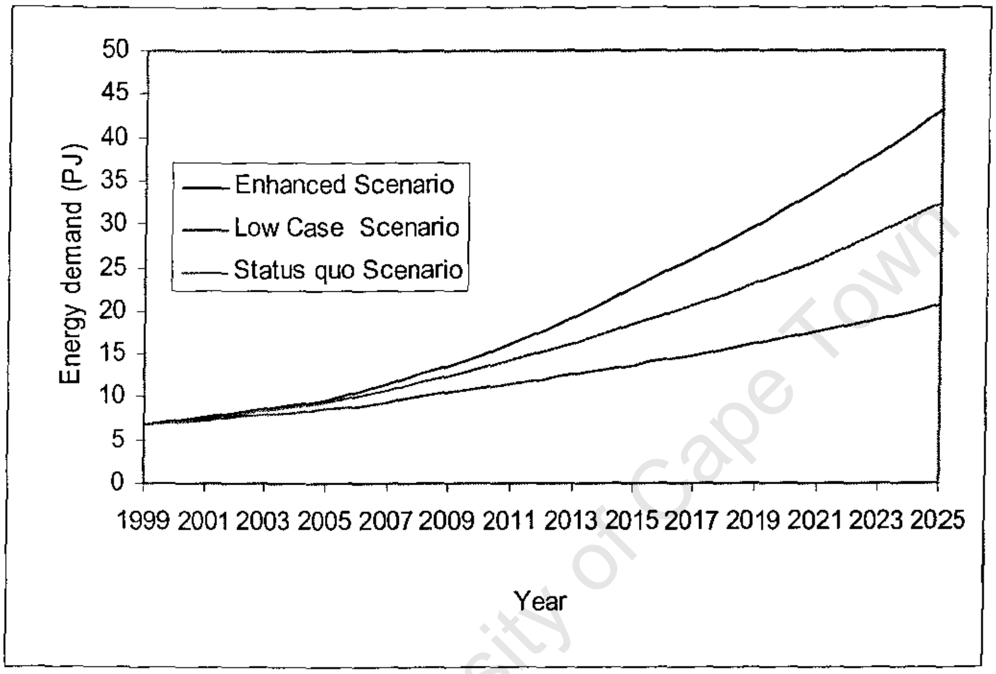


Figure 7.21 : Energy demand trend by freight transport

The use of rail in freight transport is still very low. It was assumed that if the rail network is rehabilitated, in Status quo Scenario, the rail contribution to the freight sector would increase from 2.9 % to 5% by 2025. In the Low Case Scenario, the contribution of the rail transport would be 3% and in the Enhanced Scenario, the contribution of rail in freight transport could reach 10%.

Air Transport

Air Transport is assumed to be closely related to economic development and stability in the country. It was assumed that the energy demand in the air transport sector is linked to GDP. It was assumed that as the economy improves and stability is maintained, there would be more movement of businesspeople and tourists. The projected energy demand in the air transport growth rate is above the GDP. The demand for air transport with respect to GDP elasticity for the three scenarios is as shown in Table 7.34.

Table 7.34: Air transport demand elasticity for the three scenarios

Scenario	1999-2005	2006-2010	2011-2015	2016-2020	2021-2025
Status quo	1.12	1.11	1.10	1.10	1.00
Low Case	1.10	1.10	1.10	1.00	1.00
Enhanced	1.10	1.10	1.00	1.00	0.90

In the Status quo Scenario the air transport sector energy demand would increase from 1.67 PJ to 7.62 in 2025. In the Enhanced Scenario, the energy demand could reach 11.49 PJ. In Low Case Scenario it would be 4 PJ in 2025. The trend in energy demand in air transport sector is as shown in Figure 7.22.

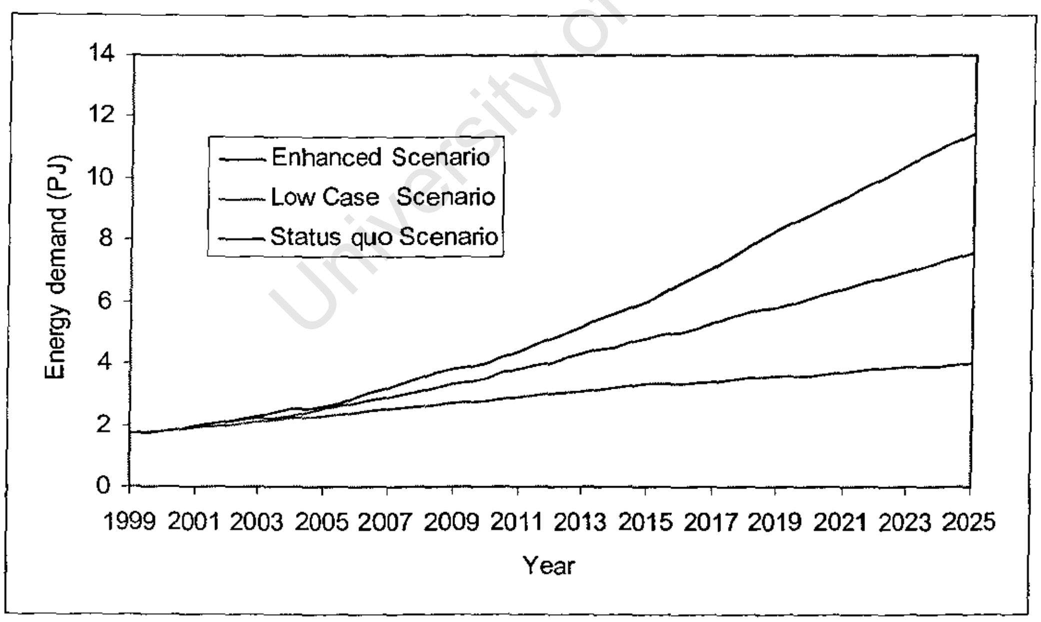


Figure 7.22: Energy demand trends in the air transport sector

7.9 Energy Demand by Type

The energy demand for the three major forms of energy sources, namely biomass, electricity and petroleum products are presented in this section. The biomass energy (firewood and charcoal) demand is expressed in terms of round wood equivalent.

7.9.1 Biomass

The forests are the major source of energy for the domestic and industrial sectors. In this case the woodfuel used for charcoal production is computed to equivalent round wood by considering the efficiency of conversion by weight. The conversion efficiency of charcoal to round wood equivalent by weight is 15 %. The demand in terms of round wood in the three scenarios is as shown in Figure 7.23.

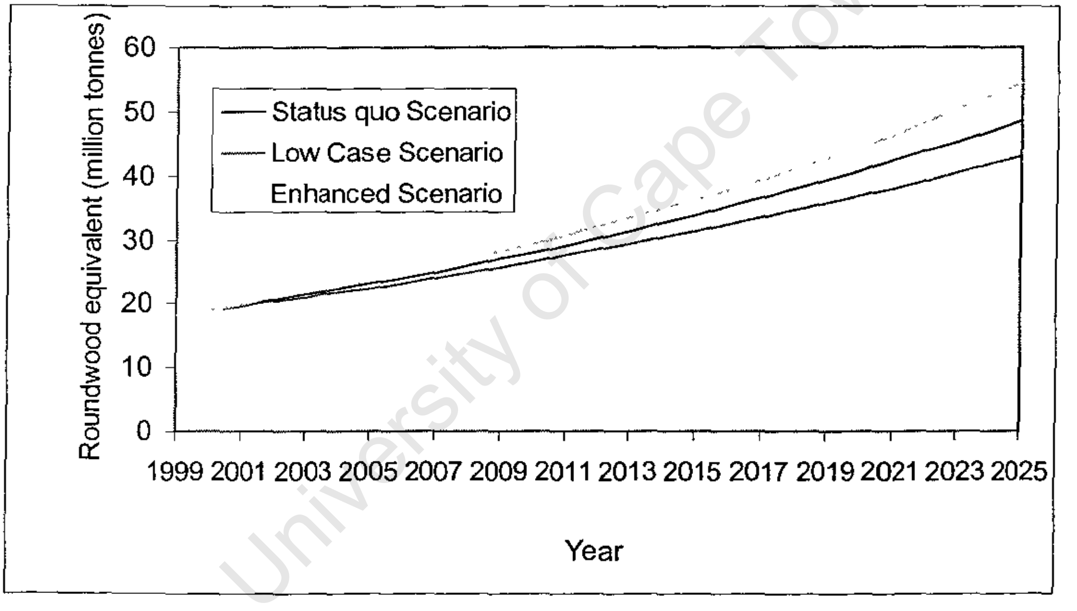


Figure 7.23: The trend in biomass demand of the round wood equivalent

In the Status quo Scenario, the wood equivalent would increase from 18.2 million tonnes to 48.5 million tonnes by 2025. While in the enhanced scenario, the round wood equivalent would reach 54.5 million tonnes. In the Low Case Scenario the demand round wood equivalent would be 43.1 million tonnes.

The projected energy demand in terms of round wood equivalent is lower in the earlier studies because of the following reasons. At present population growth rate is 3.4 % per annum while in the earlier studies it was taken as 2.9 %. In the earlier study, business as usual scenario, the projected fuel wood and charcoal demand in terms of round wood equivalent would be 29.8 million tonnes in 2012.[396] But in this study, in the Low Case Scenario, total woodfuel energy demand for all sectors in terms of round wood equivalent would be 28.4 million tonnes. In the Enhanced Scenario the demand would be 32.2 million tonnes.

There is a very poor uptake of improved efficient kiln technology. Charcoal producers do not have the initial capital to invest in improved kilns. It also takes a long time to set up the system and the systems are not portable. The charcoal producers still prefer traditional kilns since they require much less investment. It is possible to improve the efficiency of traditional kilns to between 20%-25%, with improved tending.

The use of charcoal would increase because of the high costs of modern alternative fuels such as electricity and LPG and their appliances. It is important to monitor the development of charcoal use as it entails enormous negative impacts on the total woodfuel consumed and its effects on indoor air pollution. At present there is no large-scale commercial charcoal production in Uganda.

7.9.2 Electricity

Generally it is not possible to estimate the electric energy demand based on the consumption data given over the last decade. That is because there were fluctuations in consumption. That was brought about by disconnecting the defaulters and illegal consumers. The demand for electricity is higher than supply. EDF has made several studies to forecast electricity energy demand, the latest being in 2001.

The most important source of electricity supply in Uganda is from hydropower stations. In the base year system losses as a percentage of power generated was 39.7%.[397] The transmission losses were 33 % of the total energy dispatched. In the Status quo Scenario electricity demand without transmission loss would increase from 3.22 PJ 22.24 PJ by 2025. In the Enhanced Scenario the energy demand would reach 31.47 PJ by the year 2025. In the Low Case Scenario the electric energy demand would be 16.17 PJ. The projected total electric energy demand without transmission losses is as shown in Figure 7.24.

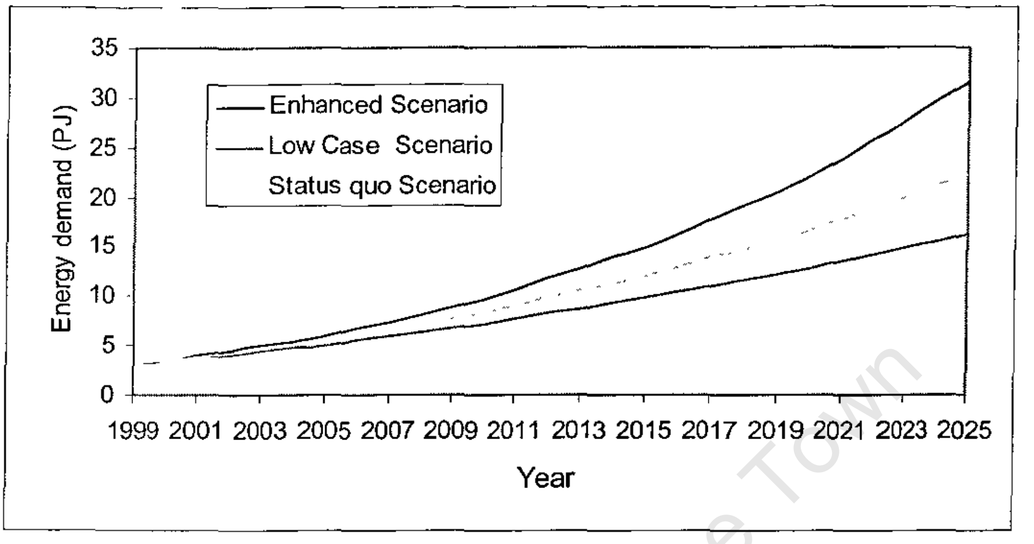
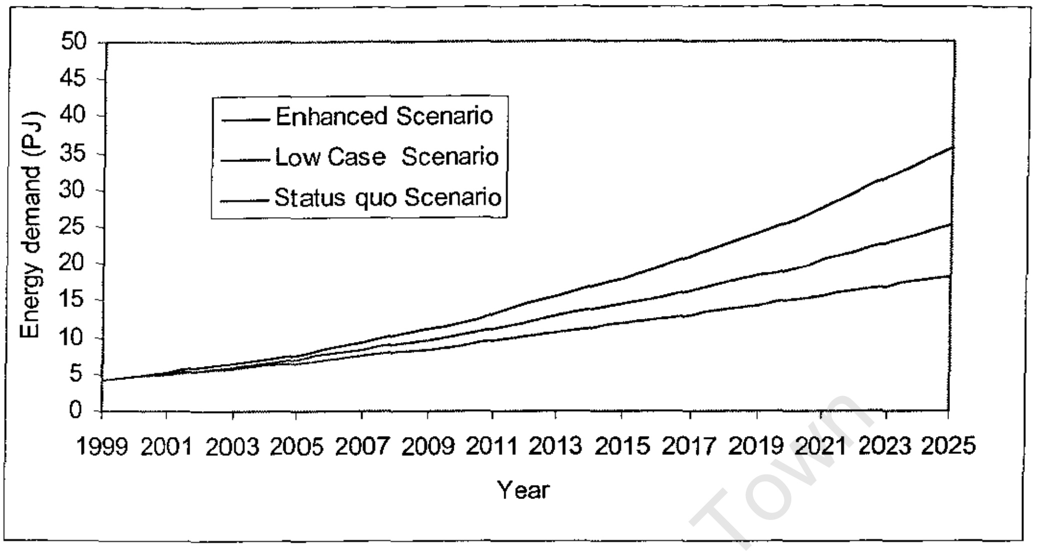


Figure 7.24 : Projected electrical energy demand without transmission losses

In the Status quo Scenario, electricity demand would be 16.56 PJ by the year 2020. In the most recent study made by EDF, the energy demand would be 18.5 PJ. It is higher than what is projected in this study due to differences in projected economic growth rates. EDF assumes a higher economic growth in the Base Case Scenario of over 6% per annum, while in this study the economic growth rate was projected at 5 % per annum. However in this study, in the Enhanced Scenario the forecast energy demand would reach 21.98 PJ by the year 2020.

Transmission Losses

In this study, it is assumed that the system losses would gradually decrease from the present 33 % of the total energy dispatched to 15 % by the year 2025. That could be done by improving the existing infrastructure, construction of modern transmission lines and improved control systems. In the Status quo Scenario energy demand would increase from 4.28 PJ to 25.13 PJ in 2025. The energy demand in the Low Case Scenario would be 18.27PJ in 2025. In the Enhanced Scenario the energy demand could reach 35.56 PJ by the year 2025. The projected total electric energy demand with transmission losses is as shown in Figure 7.25.



7.25 : Projected electric energy demand without losses (1999-2025)

In the Status quo Scenario the losses were assumed to reduce from 33 % to 16.8 % in the year 2020. In the Enhanced Scenario electric energy demand with losses would be 27.72 PJ, while in the Status quo Scenario it would reach 19.34 PJ by the year 2020. In the EDF study it was assumed the losses would decease from 30.3 % in year 2000 to 14 % by the year 2020. According to the EDF study, in the Status quo Scenario, electric energy demand would be 21.5PJ. In this study, in the Status quo Scenario, the result was 10% lower than that of the study carried out by EDF because of the differences in projected losses up to the year 2020.

Electricity Demand in MW

There is a need to supply energy to meet the peak load. That can be done by increasing the installed capacity of hydropower plant. The projected demand in MW for the three scenarios is as shown in Figure 7.26.

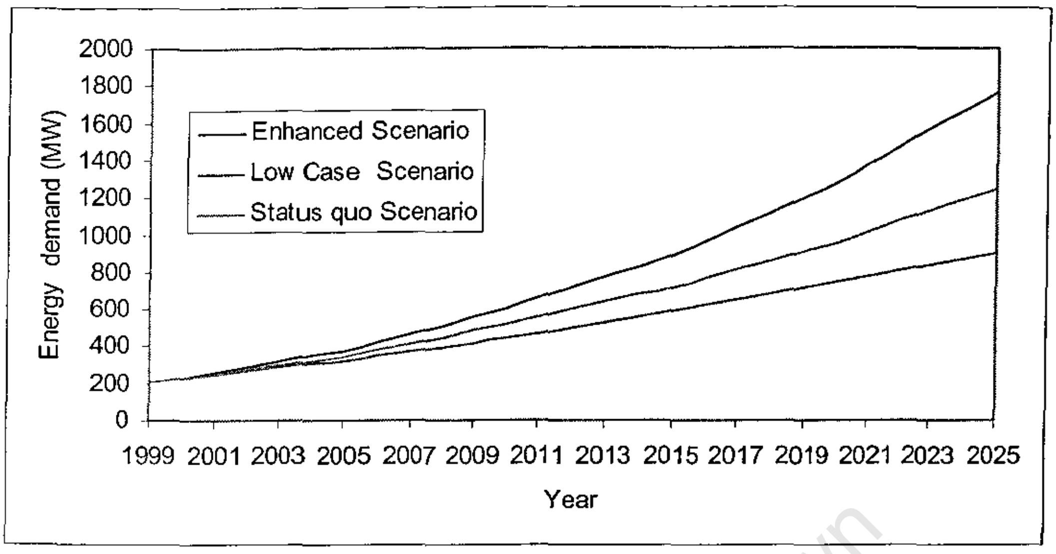


Figure 7.26: Projected demand for the three scenarios in MW

In the Status quo Scenario the demand would increase from 212 MW to 1245 MW in 2025. In the Enhanced Scenario the demand would reach 1761.92 MW by the year 2025. In the Low Case Scenario the demand would be 905.52 MW.

In the Status quo Scenario the peak demand would be 958.34 MW in 2020. In the Enhanced Scenario the demand would reach 1271 MW in 2020. The study made by EDF in the Base Case Scenario the peak demand forecast for the year 2020 was 1034 MW. When compared with the EDF study, in the Status quo Scenario peak demand is lower by 7.3%.

Electrical energy demand by sector

Basing on the Status quo Scenario, the electricity demand for each sector would increase at different rates depending on the driving parameters. Electric energy demand in the household sector would increase from 1.4 PJ to 8.7 PJ by 2025. The growth is over 6 fold. In the industrial sector, electric energy demand could increase from 0.8PJ to 7.8 PJ that is from 1999-the base year to 2025. The growth is over 9 fold. The remaining sectors show a growth of 5 fold. Status quo sector-wise electricity energy demand trends are as shown in Figure 7.27.

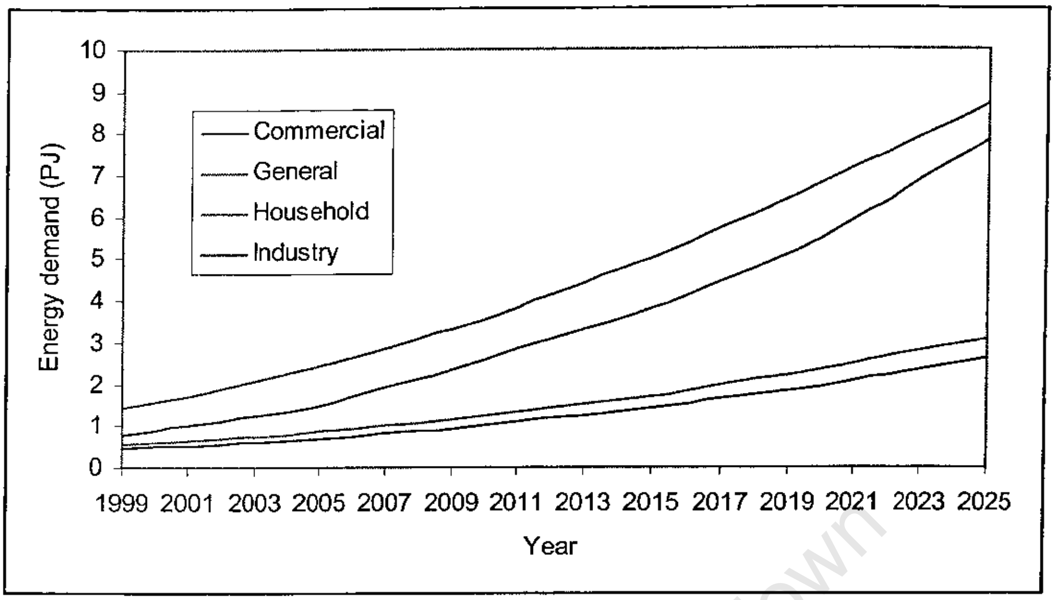


Figure 7.27: Status quo sector-wise electricity energy demand trends: 1999-2025

As seen in Figure 7.25 above, the demand for electricity increases at different rates. The composition of sector demand for electric energy in the Status quo Scenario is as shown in Table 7.35.

Table 7.35: The composition of sector demand using the status quo Scenario

Sector	Base year (1999) (%)	2025 (%)
Household	44	39
Industrial	24	35
Commercial	14	12
General	18	14

In the Status Quo Scenario the household sector would be the leading consumer of electricity followed closely by the industrial sector. In the Status quo Scenario, the results of this study of electric energy demand per sector for 2020 were compared with EDF study. The comparisons are given in Table 7.36.

Table 7.36: Comparison of sectorial electric energy demand forecast (2020)

Sector	EDF Study (PJ)	Research (PJ)	Differences (%)
Household	8.18	8.69	+ 5.9 %
Industrial	5.89	5.47	-7.7 %
Commercial	2.09	1.94	-7.7%
General	2.35	2.35	0 %

The results are similar to the EDF study. The differences in the results could be due to the assumptions made in the two projections in connection rates, economic factors and losses.

In the Low Case Scenario, it is assumed that the environment would not be conducive for investment. The most favourable scenario is the Enhanced Scenario. The electric energy demand would be the highest. The summary of electricity demand for all the sectors is shown in Table 7.37.

Table 7.37: Summary of electricity demand for all sectors (PJ)

Scenario	Year	Sector			
		Household	Industry	Commercial	General
Status quo					
	2005	2.42	1.47	0.70	0.86
	2010	3.54	2.59	1.00	1.22
	2015	5.04	3.81	1.44	1.72
	2020	6.81	5.47	1.94	2.35
	2025	8.69	7.85	2.61	3.10
Enhanced					
	2005	2.69	1.64	0.72	0.88
	2010	4.20	3.15	1.06	1.29
	2015	6.19	5.07	1.75	1.85
	2020	8.77	7.81	2.81	2.59
	2025	11.74	12.01	4.22	3.50
Low Case					
	2005	2.19	1.39	0.70	0.83
	2010	2.93	2.05	1.01	1.16
	2015	3.95	2.87	1.41	1.59
	2020	4.99	3.84	1.89	2.13
	2025	6.07	4.90	2.46	2.74

7.9.3 Petroleum Products

It was assumed that petroleum products are used in the transport sector and kerosene is used in households. Most of the diesel is used in the transport sector. There are a few industries that use fuel oil for steam production and for clinker burning (cement industry). The fuel oil use in industries is limited to beverages, beer and milk processing plants. The projected energy demand for petroleum products is as given in Figure 7.28.

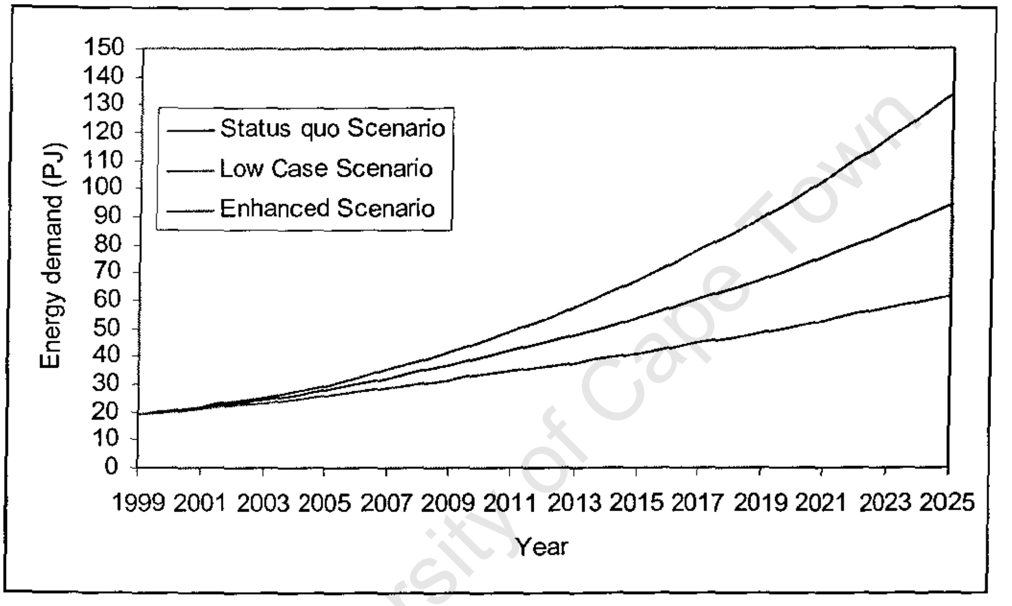


Figure 7.28 : Petroleum products demand trends

When using the Status quo Scenario, the projected petroleum product demand increases from 19 PJ in 1999 to 94.4 PJ in 2025. In the Low Case Scenario, the demand would be 61.7 PJ by the year 2025. In the Enhanced Scenario, it was assumed the pump price of fuel would decrease and that would lead to higher consumption of fuel. In this case the energy demand would reach 133.5 PJ by the year 2025.

7.10 Environment Loading in the Transport Sector

It is estimated that over 60 % of all the vehicles travel within a radius of 60 km from Kampala. There are often traffic jams during the rush hour. Kampala City has narrow roads and limited road furniture. Since nearly all the vehicles were previously owned, it is compounding environmental loading problems in the transport sector.

There are possibilities of securing funds for improving the transport infrastructure and road furniture, so that the environmental loading could be reduced. The sources of the funds could be from global environmental facilities, CDM or the Carbon Prototype Fund.

The total global warming potential (CO2 equivalent) for the transport sector is as shown in Figure 7.29.

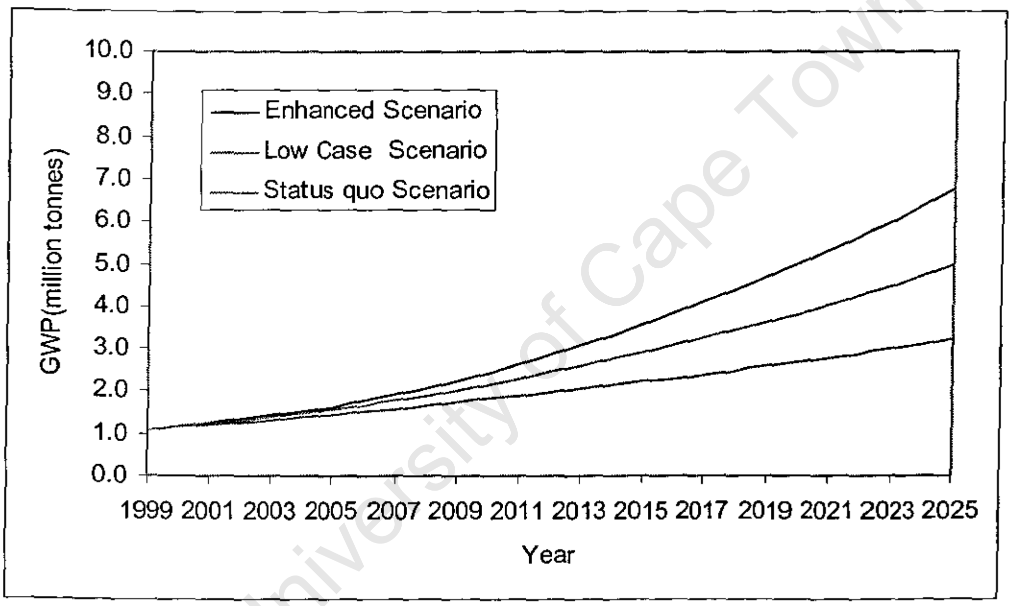


Figure 7.29: Total global worming potential in the transport sector (1999-2025)

In the Status quo Scenario, the total global warming potential (CO_2 equivalent) increases from 1.10 million tonnes to 4.96 million tonnes in 2025. In the Enhanced Scenario, the global warming potential reaches 6.75 million tonnes by the year 2025. In the Low Case Scenario, the least desirable case, the global warming potential would be 3.23 million tonnes in 2025.

At international standard, the environmental loading due to transport sectors is low. That is because the vehicle density is low when compared with other countries. Most the vehicles are second hand vehicles that are even well maintained. The roads both in urban and rural are not well maintained. Roads in the urban areas such as Kampala where over 55 % of the traffic is concentrated, are narrow and have limited road furniture which lead to traffic jams in the city. When these factors are combined, they lead to excessive fuel consumption.

The government could encourage garage owners to set up maintenance facilities by providing tax incentives. The international community can assist the country by providing grants and long term soft loans to finance infrastructure like highways and to improve traffic flow in the urban areas. The use of mass transit systems in Kampala is not feasible in the near future, because the urban transport industry is run by private organisations. They would frustrate all efforts to introduce mass transit systems in the urban areas. As far as long distance travel is concerned i.e. 150 kilometres and above the use of 60 seater buses are common.

There are other ways that the environmental loading can be reduced. Ethanol could in future be produced and blended up to 20% with gasoline, without changes required to engines. The use of 100 % ethanol or higher blending rations may have a negative effect on the environment unless properly designed vehicles and appropriate accessories are used. At present the production cost of ethanol in Uganda is high. With financial support from funds that could be used for climate change mitigation, the cost of ethanol production in Uganda could be reduced to economical levels.

CHAPTER EIGHT

ENERGY SUPPLY PROJECTION

8.0 Energy Supply

The main source of biomass is the natural forest, woodlands and plantations. Biomass energy supply has not attracted considerable concern from government and other stakeholders. The estimated gross biomass supply from all biomass cover in Uganda is 468 million tones of air-dry equivalent. [398]

The main source of electricity is hydropower on the River Nile. It is projected that the main source of electricity would be hydroelectric plants, as there are numerous sites countrywide. The sites have an installed capacity of less than 10 MW each, which could be developed by private companies. It is estimated that private developers can generate a total of 70 MW when sites are exploited. A few international companies have expressed interested in hydropower generation. Diesel power generators are used in the towns and other essential load centres that are not connected to the main grid. Another attractive option is geothermal.

Uganda would depend on imported petroleum products in the foreseeable future. The proposed construction of pipeline could reduce transportation cost. There is hydrocarbon potential in the western part of Uganda. Test drills are going in various places including Semliki, Waki and Para. The energy resource could be developed by the private sector.

8.1.1 Biomass growth and yield

At a national level Uganda one can ideally expect a yield of 50 million tonnes of biomass per year. 15 million tone of the biomass is protected. A balance of 35 million tonnes are on private land. The private land covers over 84% of the total land. Human activities and natural factors influence the net biomass growth. The protected areas are assumed to be under proper management and not as vulnerable as the private areas. The result from the biomass study [399] is presented in the Table 8.1.

Table 8.1: Future Scenario for biomass

Land cover	Private (000 tonnes)	Annual loss /gain (000 tonnes)	2000	2025
Hardwood Plantation	1,059.6	0.0	0.0	0.0
Confer plantations	103.6	0.0	0.0	0.0
Tropical high forest (stocked)	31,8432.3	-4.201	27,642	-77,388
Tropical high forest (depleted)	18,050.2	-1.476	16.574	-20,318
Woodlands	101,071.7	-5,929	95.143	-53,047
Bush land	11,413.3	-710	10.704	-7.035
Grassland	36,994.3	-185	36,809	32,185
Wet land	230.0	0.0	230	230
Subsistence farmland	110,513.6	497	111,011	123,436
Large scale farmland	150.5	0.0	151	156
Built up area	850.2	4	855	964
Water	0.0	0.0	0.0	0.0
Impediment	0.0	0.0	0.0	0.0
Total	312,280	-11,999	299,119	-846

The biomass held in the tropical high forest, woodland and bush land would be depleted by the year 2025. The land in the private areas would be covered by grassland, subsistence and large-scale farmlands. Neither the grassland nor firm land is the major source of fuel wood for both household and small scale industries in the rural areas. However though the results do not tell us when the crisis would begin, there would be a biomass deficit by the year 2025.

The land cover distribution is shown in Appendix A Figure 8.1. The distribution of the land cover by percentage is shown in Figure 8.1.

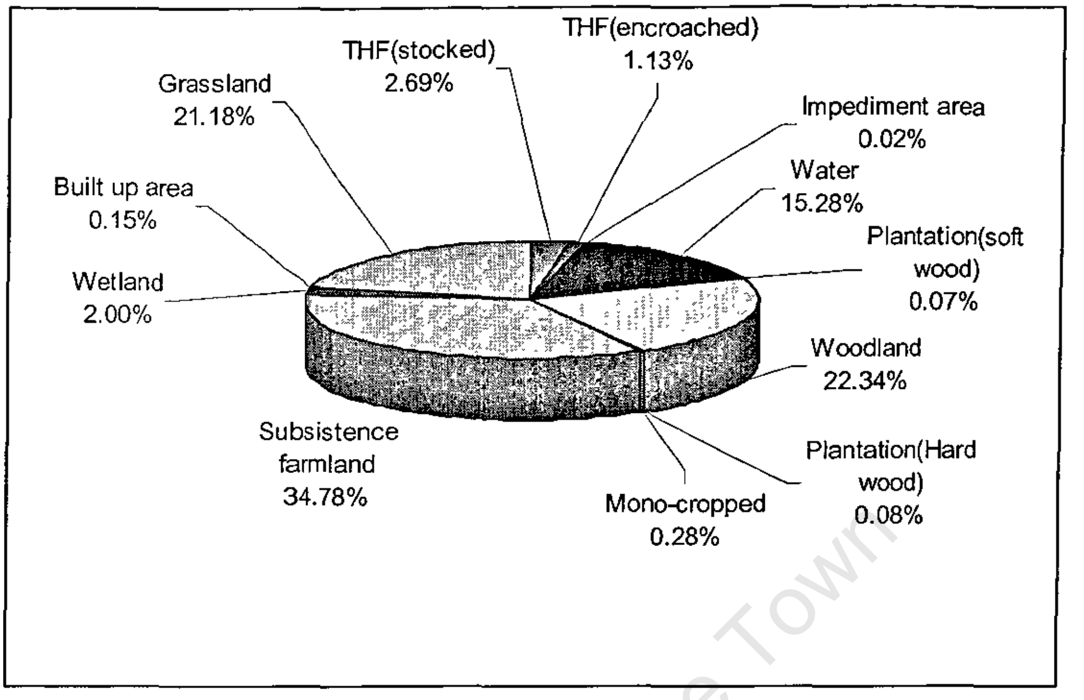


Figure 8.1 : Distribution of land cover

The woodland and grassland cover most of the areas. Although subsistence farmland covers less than 35 % of the total land areas, it would increase with the increasing population. Clearing land for agriculture is one of the main causes of deforestation.

8.1.2 Woody Biomass Availability

The gross supply assumes that all biomass is accessible to the population. In reality not all the biomass would be available due to factors like the size of trees, accessibility and areas such as forest reserves and national parks. Domestic fuel wood consumption is generally not the largest destructive force in Uganda's forest. Land clearing for agriculture has a greater impact on deforestation. The map showing wood fuel availability is illustrated in Appendix A Figure A8.2.

Whereas in some areas the consumption of biomass is above the sustainable yield, in other areas there is scarcity and in other areas wood fuel is a surplus. Households have a number of coping strategies, of which tree planting and energy saving stoves are just two of the alternatives.

8.1.3 Peri Urban Plantations

A total of 3,704 ha of peri-urban plantation had been established by 1998, of which 41 per cent were on private pilot wood farms. Plantations are an important source of firewood and poles for urban areas. It is problematic to lease and develop forestland in the peri-urban areas because changes in priorities by central government. These areas are seen to be more viable for industrial use than to provide a green belt near major cities and towns.

8.1.4 Commercial Sector

There is wide use of biomass resources in small-scale industries, as well as in a few large-scale industries. The industries of interest are brick making, lime makers, fish drying, tobacco growers, and tea and sugar estates. They meet their demand from sources depending on the availability of wood fuel. The main source of biomass is the natural forest but there is a growing supply from plantation sources due to the dwindling natural forests near the sites.

The people who are involved in the informal sector generally buy from wood fuel from suppliers. The reason is that they do not own land to plant trees. Furthermore the there is limited alternative fuel for commercial sector.

Most lime producers are concentrated the limestone deposits. Lime burners generally buy fuel wood. These areas are exhausted of natural forests and a market for wood fuel from eucalyptus is emerging in the areas further from the sites.

The introduction of energy saving devices and tree planting initiative among fishermen has had mixed results, depending on the relative wood shortages, and economics of adopting improved kiln technology. [400] The transient nature of fishing communities and insecure land tenure makes it hard to plant trees. The fishermen at times migrate depending on the seasons.

8.1.5 Tobacco

In a bid to increase biomass supply, BAT has instituted a policy of not contracting any tobacco farmers who do not own at least 500 surviving trees. This would provide a sustainable level of planted wood fuel for all tobacco curing. Adaptation of efficient barns would also reduce wood fuel consumption. The wood supply is based on tobacco need. It would be advantageous if the sources could be expanded to cover household needs. There is a deficiency of biomass in the areas where there is intensive cultivation of tobacco.

8.1.7 Tea and Sugar Factories

A large amount of energy is required for processing tea and sugar. Most of the tea and sugar estates are self sufficient in wood fuel. Companies use woodfuel because it is a cheaper source of energy than electricity and petroleum products for drying processes. The main reasons why the tea and sugar estates have opted for the establishment of their own plantations is to ensure a reliable supply of biomass for processing their raw materials. The sugar factories rely on bagasse-fired boilers as the main energy source. They use very inefficient boilers, with the intension of disposing off the excess bagasse. But in the near future, the use of efficient boilers and power generation using excess bagasse would be devised.

8.1.8 Private Timber Producers on Reserve Land

Tree planting is a commercial activity with a long investment period and considerable risks and uncertainty. Financial profitability is the overriding factor that determines whether a timber plantation is established or not. The Forest Department issues Land use permits to private companies for timber and carbon plantations on a number of denuded forest reserves. The land use permits extend over a period of 30 years or more.

The Forestry Department concession is renewed annually and planted trees remain the property of the Forestry Department. Tree planting under the concession contracts has generally been extremely poor. The main reasons are the lack of security of contract and tree tenure and poor sources of seed. Additionally, the Forestry Department often lacks money to implement their policies.

8.1.9 Charcoal

The charcoal producers are among the poorest stakeholders, and are generally not organised. In some areas trees are felled for charcoal production. Charcoal is also often a by-product of land clearance for agriculture or livestock developments on fallow land The main source of charcoal is the mid-western and central region. This land cover for this 700,000 ha area is woodland. The charcoal producing region is as shown in Appendix A Figure A8.3.

The dynamic assessment indicates that tree biomass stock is declining at a rate of 1.9 tonnes per hectare annually. That is about 1.3 million tonnes per annum from 700,000 ha. Since 3 million tonnes are required for charcoal production, this means that 1.7 million tonnes must come from other sources such as trees and land clearance for agriculture [401]. The future of charcoal production in this area is not sustainable

8.1.10 Biomass supply

The future Scenario shows that the consumption of biomass would be above the sustainable limit. Most of the forests are on the private land. The accessibility and management of these resources is crucial in future biomass energy supply. The trend shows the sustainable yield for energy and round wood equivalent consumption for the three scenarios are shown in Figure 8.2.

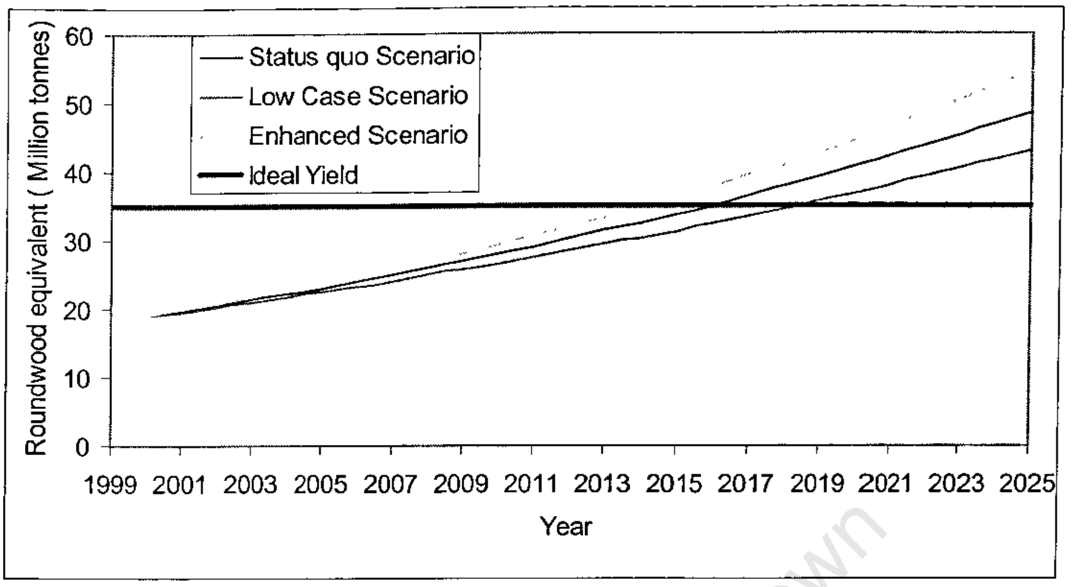


Figure 8.2: Round wood equivalent ideal yield and demand for three scenarios

If it is estimated that the yield from the private land is 35 million tonnes per annum, and energy demand for the three scenarios in terms of round wood equivalent is as shown in above Figure 8.5. This implies that between 2014 and 2019, the demand for fuel wood would be above the sustainable ideal yield. But in actual sense, there are other activities like land clearing for agriculture and grazing, harvesting of forest products for other purposes. That means the demand for round wood equivalent is higher than illustrated above. It should be noted that source of wood would be shifting from high to less populated regions.

It is most likely that within ten years, there would be wood fuel deficit in most of the country. The gap between the supply and demand would increase well above the sustainable yield in 2014. The year would be the beginning of fuel wood energy crisis, if wood supply issues are not effectively handled by 2008. The implication is that by 2014 Uganda would have started using energy from the standing stock. That would be the on set of fuel wood crisis. With the limited awareness by the populace of the looming woodfuel shortage, it is expected that the crisis would get worse.

There is need to start drives to increase awareness; the forest reserve for energy, better management of private forests and improved farming practice so that the yield is maintained at 35 million or more tonnes per annum. It can be seen clearly that the biomass energy supply is not sustainable in all the three scenarios.

8.2 Development of Electricity Power Plants

The development of hydropower plants in Uganda takes long time before it is implemented due to financial constraints and environmental considerations. It is assumed that the remaining two turbines of 40 MW each could be installed in Kiira hydroelectric dam in the near future. That would have raised the total installed capacity to 397 MW. But of recent there is a drop in level of Lake Victoria. It is envisaged however that the large capacity hydropower stations could be developed in separate stages, so that generation would match load growth rates.

It was invisaged that Bujagali hydroelectric dam will be developed in the year 2009 and that would be followed by the Karuma hydroelectric dam in 2010. It is most likely that Kalagala hydroelectric dam would follow. Ayogo North and Ayego South hydroelectric dam may follow suit. Murchison Falls is liked to be developed last because it may face a lot of opposition from environmentalists.

It was assumed that there would be improved electricity supply that would minimise losses. In this study, additional 10% reserve capacity for each of the scenarios was required to cover any surplus demand of electricity. It was assumed that with the liberalisation of the electricity sector, private companies would invest in infrastructure to improve on the delivery of electricity. Consequently the projected losses would decrease from 33% (in 1999-the base year) to 13% by the year 2025.

Electricity domestic need

The Status quo Scenario shows that electricity demand would increase from 233.41 MW to 1369 MW in 2025. Load shedding could continue to be experienced at different levels until the year 2009, when another hydropower station is completed.

In the Enhanced Scenario, the electricity demand would reach 1938.14 MW by the year 2025. The electricity demand would be high in the industrial and household sectors. Load shedding would persist and it would get worse from 2013 to the year 2025. The country would have to start importing electricity from Southern African Power Pool as early as 2010. The electric energy demand, surplus /deficit for the three scenarios are as shown in Figure 8.3.

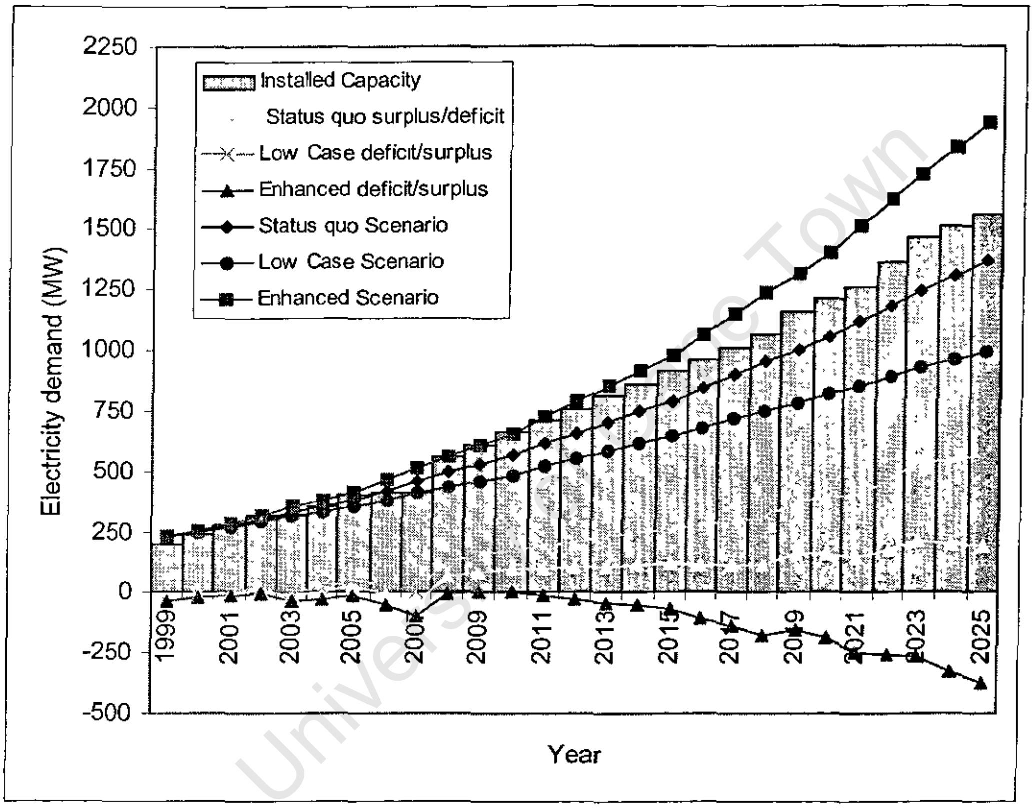


Figure 8.3 : The electricity demand, surplus /deficit for the three scenarios (MW)

In the low case scenario, it is anticipated that there would be a low level of commercial and industrial development. The electricity energy demand would reach 995.85 MW. This would imply that Uganda can export up to 564 MW of electricity to the neighbouring countries during the peak hours.

Electricity for Domestic Use and Export

After meeting domestic electricity need, Uganda could export electricity to the neighbouring countries. The export would be made either during the off peak period or any time depending on the domestic need. The projected exports to Kenya and other neighbouring countries may be resumed after 2009. Initially the exports would be increased from 50 MW thereafter it would be increased to 80MW when other dams are built. For all the scenarios, exports can only be made during the off peak period. The electricity for domestic and export scenarios illustrating surplus/deficit are as shown in Figure 8.4.

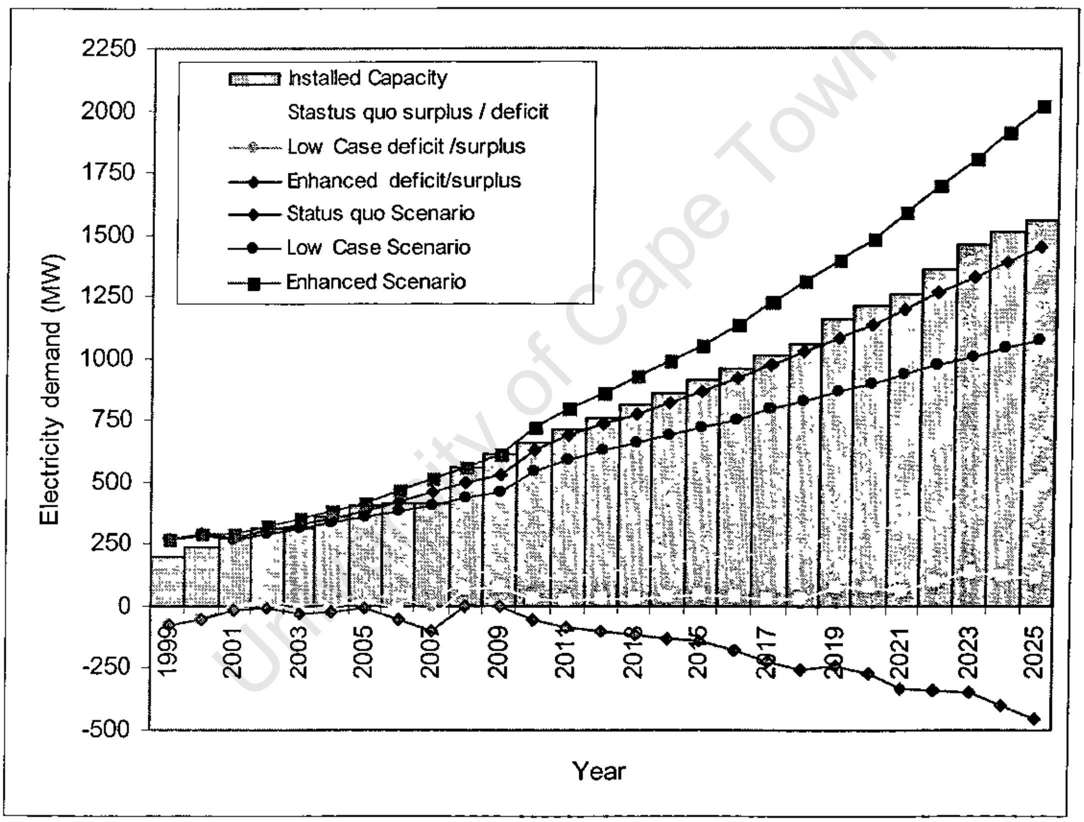


Figure 8.4: The electricity for domestic and export scenarios, surplus/deficit (MW)

In the Status quo Scenario, electricity can only be exported during the off peak period. With the development of the hydropower plant in the year 2009, there would be a slight increase in electricity exports to the neighbouring countries.

In the Enhanced Scenario, there would be an electric energy deficit throughout the period of the study. The deficit could get worse from the year 2010 to 2025. In this case Uganda would be an importer of electricity. If it develops its petroleum industry by the year 2015, Uganda can start using gas turbines to generate electricity. That would depend on the comparative advantage of using alternatives like geothermal plants for electrical power generation.

In the Low Case Scenario, it is assumed that there would be a low level of economic activity. Electricity exports could increase from 39.78 MW in 2008 to 474.65 MW in the year 2025.

Parallel to the development of hydroelectric plants there could be construction of power transmission lines from the plant sites to the main load centres. At present most of the high voltage transmission lines are of 132 kV capacities. The proposed new transmission lines would have a capacity of up to 220 kV.

8.2.1 Rural electrification

It is a demand driven approach to deliver power to the rural areas. The ambitious programme is to electrify 400,000 rural households in the next 10 years out of which, it was estimated that 15% would be from serviced households; 40% from interconnected grid 25% from isolated grid while 20% from photovoltaic system. [402] The players in the field are local initiatives, financial institutions and the private sector, and private sector. The main innovation of the plan is to subsidise access to energy but not the consumption.

8.2.2 On going projects

- Bushenyi and Rukungiri Rural Electrification Project. This is a small hydro plant with an installed capacity of about 5MW. The Uganda Rural Electrification Company Limited would implement the project.
- Kakira Biomass Cogeneration is planning to increase its cogeneration capacity to 14MW in the first phase and an additional 20-25 MW in the second phase. The project would be implemented at Kakira Sugar Works.

- Nyagak Hydropower Scheme with an installed capacity of 6MW and 1.5MW Hydropower plant at Olewa, in addition to a 2.5 MW diesel generation to be installed in West Nile.
- Uganda Photovoltaic Project for Rural Electrification (UNDP/GEF) US$ 1.8m is a precursor project to the ERT rural photovoltaic electrification project.
- Kisiizi Micro-hydro Electrification Project. The project could be developed and implemented by the Kisiizi Hospital, which would bring an additional 150 kW to the existing 60 kW micro hydro plant.

There are also other projects that would be coming on line. Among them are:

- PV solar systems under Energy for Rural Transformation (ERT). This is a World Bank supported programme implemented by the Ministry of Energy and Mineral Development, the private sector and other stake holders
- Mount Elgon Power Company, power supply in Mbale, Hydromax would supply to Buseruka, Masindi, and Hoima in western region.

The UPPPRE is a pilot project whose goal is to establish the foundation for the sustainable use of solar photovoltaic (PV) technology for rural electrification in Uganda. It is designed to demonstrate the financial and institutional mechanisms that would provide PV-based electrical services on a commercial basis to households, businesses and communities in rural and peri-urban areas, which are not projected to have access to grid-based electricity in the foreseeable future. The targets end users are those who have the ability and willingness to pay the unsubsidised cost of the PV systems.

In support of the UPPPRE, the Global Environment Facility (GEF) has provided funds for the provision of technical assistance, training, information collection and dissemination. In addition, a $500,000 PV credit fund has been provided by the UNDP to promote the provision of loans through local financial institutions to communities, business and households for the purchase of solar PV systems.

8.2.3 Source of Funds

The Nyagak mini hydro plant in West Nile has benefited from the prototype carbon fund (PCF). The fund has negotiated an emission reduction purchase agreement (ERPA) with the Ugandan government, which is incorporated into the bid package for insurance of the concession for providing power to a remote region. The PCF would ultimately sign an ERPA with the wining bidder. This could enable the project entity to generate emission reductions, which would provide a stream of payment of US$ 3.5 million over 16 years.[403] This additional income will not only attract project developers but also other financial institution will be willing to give loans.

8.3 Alternative Energy

Despite its abundance, solar energy utilisation is still very low in Uganda. To a limited extent it is used for the provision of lighting in rural areas and as an energy source for communication and other equipment. The thermal application of solar energy, as in water heating, is still very limited. Wind energy is limited to water pumping.

CHAPTER NINE
CONCLUSIONS AND RECOMMENDATIONS

9.0 Introduction

The conclusions and recommendations are grouped into five categories, namely total energy, biomass, electricity, petroleum products and general conclusions. These conclusions and recommendations are drawn from the analysis of the scenario data that was developed in earlier sections.

9.1.0 Conclusions

9.1.1 Total Energy

- The government has energy policy in place, but is very expensive to impalement.
- The demand for biomass and electricity is growing faster than supply. Since biomass is the largest source of energy, unsustainable exploitation of the biomass resource base and associated environmental concerns is eminent and likely to cause severe shortage and environmental degradation.
- There is limited local energy planning expertise. The Ministry of Energy and Mineral Development relies on technical assistance from foreign countries. Consequently, there is an over-dependence on other countries for expertise and resources. When the experts depart, energy planning and necessary modifications cannot be carried out by the local experts and personnel. The use of foreign experts forces the country to make compromises; which could be against the national interest in the long term.
- There is a lack of coordination of energy-related activities between ministries, department and academic institutions, which results in duplication of effort, time wastage and resources under utilisation.

9.1.2 Recommendations

- The government should increase funds for energy-related policy awareness campaigns. Furthermore the government should enable effective participation of the populace and local experts in energy policy awareness and lobbying schemes.

- Since biomass is the largest source of energy, the government should focus more on increasing biomass supply. The government should put in place favourable policies that allow investments in forest sector. The government should embark on comprehensive programme to publicise looming biomass crisis and the hydropower shortage. The international community should be lobbied to assist by giving grants, soft loans and technical assistance for development of the energy resources. The government should guarantee loans to private sector to develop hydropower resources.
- There is a need to develop national capacity by training staff in energy planning, by designing and implementing. A compressive energy-training programme should be designed. A joint action by the Ministry of Energy and Minerals Development, institutions of higher learning and other stakeholders should be devised. This will improve on coordination of energy activities at national level. The use of an international expert in the short term would have an estimated cost of US$ 60,000.

9.2.0 Biomass

9.2.1 Conclusions

- There is over-exploitation of biomass resources to unsustainable level in some parts of the country. At present about one-third of the country has an excess of biomass, while the rest will be in deficit in the near future. The main causes are firewood demand for households that often use inefficient stoves and other commercial activities such as brick, lime and charcoal production. As the result of these trends, the consumption of biomass will exceed sustainable yield and there is likely to be biomass crisis in the foreseeable future.
- There is general deforestation and land degradation in most some parts of the country. Forest reserves are not well managed. There is limited investment by the private sector in forestation and peri-urban plantations at national level.
- The high population growth rate is increasing pressure on land and the biomass resource base. More land is being cleared for agriculture and pasture to feed the

population, these exuberate deforestation. As the result, it leads to encroachment on forests reserves and competition for land.

- The frequency of conducting household energy surveys is too low, it is about once in a decade. Currently the data is often not readily available when required, for purposes of energy planning and policy formulation.
- Most of the households are using inefficient stoves. Most of the kitchens are not well ventilated. The use of biomass generates particulates and gases such as carbon monoxide, especially charcoal and carbon dioxide due to incomplete combustion of biomass, which leads to indoor air pollution. These particulates and gases are harmful to human heath, especially to women and children.

9.2.2 Recommendations

- The Ministry of Energy and Mineral Resources should initiate a project to reintroduce, produce and market improved stoves in the urban areas and earth stoves in rural areas. The project could be demand driven and facilitated as well as providing technical assistance by development partners, private sector and NGOs assisting in the promotion. A two-year sustained advertisement and promotional programme would cost US$ 558,000.
- There is a need to promote efficient kilns for charcoal, lime and brick production. Furthermore, there is a need to design and reconstruct intermediate kilns and to train lime producers. The estimated cost of modern lime kiln is US$15,000. The cost of promotion and training lime makers is estimated at US$ 173,000, while training charcoal producers would cost US$ 150,000.
- Major commercial biomass energy users like tea and tobacco producers should be obliged to plant more trees and sell to public. The Ministry of Energy and Mineral Development should promote the use of agricultural residue like coffee husks as a substitute for firewood in the small-scale brick producing industry.
- There should be continued biomass resource monitoring so that dynamics of land cover are known and appropriate action can be taken in time. This should be done at least once every ten years.

- There should be drives to increase the forest reserve for energy, better management of private forests and improved farming practice so that the yield is maintained at least at 35 million or more tonnes per annum.
- The government should initiate projects that increase fuel for local community. When considering intervention measures, the local community, the NGOs should be involved in project planning and implementation. The issue related to culture of community should always be considered. The government should encourage planting of trees in the marginal and farm lands furthermore, tree planting activities should be based an agro forestry practise. The forest should not only the source of fuel wood but also other products like fruits and local medicine. Other income generating activities for the poor like bee keeping should be encouraged. Such alternative source of income in rural community reduces pressure on charcoal production and other forms of biomass destruction. The government should encourage joint management of the forest with people who are living within the vicinity of the forest.
- The international organisations should assist private sector, through the government body like Uganda Forestry Authority with grants and low interest loans, so that they can invest in agro forestry and reforestation projects. Biomass resource management is important for it not only counters deforestation but also it sequesters carbon. The private sector can benefit from CDM projects as an alternative source of funds. The government's role will be monitoring the activities of the private sector.
- In the agricultural sector, there is a need to intensify production per unit area of land, through use of improved agricultural practices. These leave some land, for tree planting to maintain wood fuel supply and improved food security.
- There is a need improve or change land tenure system. The government should consider alternative land lease system or land sharing arrangement with people living near the government forest reserves.

- There is a need to carry out household energy surveys regularly. The data will be useful in formulation of household energy policy. Detailed energy surveys should be carried out every five years. The cost of carrying out such a survey is estimated at US$ 240,000.

- The use of efficient household stoves will not only save fuel, but they will also reduce the amount of particulates, and harmful gases such as carbon monoxide and carbon dioxide. Improved kitchen ventilation will dilute the concentration of harmful gases and lessen the impact of indoor air pollution. The government should consider subsidising LPG which is cleaner and produces less pollution than biomass based fuels such as charcoal and fuel wood. The use of biogas should be promoted in the regions where there is cattle and enough water.

9.3 Electricity

9.3.1 Conclusions

- At present there is deficit in electric energy supply, which limits economic development especially in the commercial and industrial sectors. This trend will make Uganda unattractive for foreign investment.
- There is continuous increase in electricity tariff in all sectors. The high tariff will raise the price of products manufactured in Uganda; consequently they will not be competitive in the local market.
- The level of national electrification is very low. About 40 % of the urban population and less than 1% of the rural population have access to electricity. Consequently, nearly all the industries are concentrated near Kampala city and other major towns.

9.3.2 Recommendations

- The government should initiate a favourable policy that will attract independent power producers (IPP's) to invest in electricity generation. Rural electrification should be emphasised. The Government should make a joint investment in power generation with a private sector. If properly lobbied, the World Bank and other financial institutions could increase technical assistance and funds for electricity production and improvement of the power sector. Government with assistance from development partners should study and if feasible exploit the geothermal potential in long term.

- Uganda should join the East African Power Pool, at least within the next ten years and in the long term join the Southern African Power Pool.
- In industries that have high electricity consumption, the demand can be reduced by over 20% through effective energy management This is by using energy efficient equipment, the installation of power factor correction equipment and instituting special tariffs at peak periods. The tariff for the industrial sector should be kept low compared to the other sectors to boost industrial production.
- The government should promote decentralised power systems, mostly in the rural areas. Urban areas' infrastructure should be upgraded. Energy management and other saving practises should be encouraged in all sectors.
- The government should introduce a favourable rural electrification policy for rural areas to accelerate rural electrification.
- The government should invest in transmission and distribution infrastructure in areas where it is not attractive to the private investor. The development partners should assist in funding transmission line and associated infrastructure developments.
- The private sector should be motivated to develop small-scale hydropower plants and to extend grid electricity to economically-promising sites in the rural areas so that industrial and commercial development will be spread country wide. The government estimated that to increase rural electrification from 1% to 10% would cost US$ 440 million. It would be desirable to increase rural electrification (both grid and other alternatives) to 20% by the year 2025 and this is estimated to cost US$ 880 million.

9.4 Petroleum Products

9.4.1 Conclusion

- The consumption of petroleum in the transport sector is increasing due to the high increase in the number of vehicles. This implies that the number of trucks that will transport petroleum products will increase. That will cause excessive pressure on the infrastructure (road, rail and marine).

- Most of the roads in Kampala are narrow and lack road furniture. Most of the vehicles are second hand. As the result, fuel consumption is high. Consequently amount of greenhouse gas loading and air pollution in the atmosphere is accelerated.
- Fuel is expensive. The increasing demand will raise the need and competition for foreign exchange. This negatively affects all other sectors of economy.
- The energy demand in aviation sector will increase as rehabilitation and opening up of the closed airfields occurs. There are increasing numbers of non-scheduled and scheduled local and international flights.
- Most of the railway line is in a bad state. The poor rail systems have increased pressure on road infrastructure. The movement of bulk commodities by road is expensive.

9.4.2 Recommendations

- There is a need to extend and increase the pipeline from Eldoret to Kampala. The estimated cost is US$110 million. In the longer term, the government should institute a favourable policy for petroleum products exploration and exportation. The government should seek for funds for exploration of petroleum products.
- The government should improve the infrastructure; by widening roads and installing road furniture in Kampala, which would ease traffic flow. This is estimated to cost US$ 66 million in the next twenty years. The national road system maintenance is estimated at US$ 587 million in the next twenty years. The government should seek for loans and grants from international financiers and partners for assistance, in urban and national road work infrastructure development. Good infrastructure will reduce petroleum consumption, environmental loading and competition for foreign exchange.
- The government should consider limiting the age of vehicles imported; by putting in place deterrent policies such as heavy taxation. The culture of vehicle maintenance should be initiated, promoted and supported.

- Energy management practice and other energy saving opportunities should be initiated and encouraged in energy intensive industries. Furthermore where fuel switching is possible, the cement and brick making industry could use biomass instead of fuel oil. At the Hima cement factory the use of coffee husks instead of fuel oil saves the firm about US$ 20,000 per annum.
- As the economy improves, since the numbers of international flights will increase, the demand for local flights will also increase. The government should rehabilitate the air field and construct new ones in tourist areas and commercial centres. The investment for improving air traffic system is estimated at US$ 152.4 million.
- The government should rehabilitate closed railway lines as the country enjoys political stability and economic development. As per the study carried out by CANARAIL, the estimated cost of rehabilitation of the main line, re-opening closed routes and to carry out maintenance at railway yards is estimated at US$ 31.5 million. [404]

9.5 General Conclusion

The importance of adequate, reliable and affordable energy cannot be overemphasised. The growth of the economy and the accompanying social and economic development depends on, amongst other things, the availability of energy. It would be tragic if the only ingredient missing for growth were energy. It is imperative that the recommendations of this project enjoy serious consideration, and where appropriate, are implemented without delay. There is a need for partners in development of the energy sector. International institutions are required to assist the government financially; by giving loans and grants to develop infrastructure. The government must endeavour to provide for maintenance of the infrastructure.

REFERENCES

[1] Government of Uganda.((2004, June). Background to the Budget for Financial Year 2004/05, Ministry of Finance Planning, Planning and Economic Development, Kampala, p40.

[2] Ibid

[3] Uganda Bureau of Statistics. (2000, June). Household Survey 1999/2000. Entebbe p.10.

[4] Ibid p11

[5] Ministry of Energy and Mineral Development. (2003, April). Uganda National Energy Balance. Kampala.

[6] Ibid

[7] Ibid

[8] Virate Tig Tuntivate.(1997, September). Uganda Non Grid Rural Electrification, Analysis of Household Energy Survey. Ministry of Energy and Mineral Development. Kampala

[9] Electricity Regulatory Authority. (2005, April 11). The New Vision, p 18.

[10] Politicians to Blame for High Power Tariffs. (2005, April,11). New Vision, p6.

[11] Ministry of Energy and Mineral Development.(2003,March4). http://www.energyandmineral.go.ug/UGA Energy Balance 2003 htm

[12] UNDP/ World Bank. (1996, March). Joint UNDP/World Bank Energy Sector Management Assistance Programme, Washington DC.

[13] Uganda Investment Authority. (2001,June). Energy Investing in Uganda., Industry Profile, Kampala ,p.3.

[14] Ministry of Energy and Mineral Resources (2000, June).Liberalisation of Petroleum Sub sector in Uganda. Changes and Impact, Kampala..

[15] World Bank IENPD, Energy for Sustainable Development Ltd. (1995, June).A Review of renewable Energy Resources and Technologies in Uganda Final Report, Kampala. p30.

[16] World Bank. (2005).World Development Indicators, Washington DC, p200.

[17] The Government of Uganda.((2003, June). Background to the Budget for Financial Year 2003/04, Ministry of Finance Planning and Economic Development, Kampala, p4.

[18] The Government of Uganda.((2004, June). Background to the Budget for Financial Year 2003/04, Ministry of Finance Planning and Economic Development, Kampala. p4.

[19] Ibid

[20] World Bank. (2001). World Development Indicators, Washington, DC, p 200.

[21] UNDP. (1997). Industrial Development Review Series: Uganda, Sustainable Stabilisation and Industrial Growth, New York..

[22] The Government of Uganda.((2003, June). Background to the Budget for Financial Year 2003/04, Ministry of Finance Planning and Economic Development, Kampala, p A8.

[23] World Bank . (2003). World Development Indicators, p 35. Washington, DC.

[24] World Bank. (1998). World Development Report 2000/2001, Washington, DC.p.275,

[25] Ministry of Finance Planning and Economic Development.(2003) Uganda Poverty Status Report., Kampala, p.164.

[26] Ministry of Finance, Planning and Economic Development .(1998).Poverty Trends in Uganda 1992-1996. Discussion Paper No.2, Kampala.

[27] Ministry of Planning and Economic Development.(1999, December). Vision 2025, Background Paper Vol.2. Kampala..

[28] Government to reduce HIV/AIDS to 5%. (2005,19-25 April). The Weekly Message, p16.

[29] The World Commission on Environment and Development. (1987). Our Common Future, Oxford University Press. Oxford

[30] Government of Uganda. (2002, September).The Energy Policy for Uganda, Ministry of Energy and Mineral Development, Kampala.

[31] Government of Uganda. (1999, July). The Electricity Act. Ministry of Energy and Mineral Development , Kampala.

[32] Intermediate Technology Development Group (2004, March 19). Smoke and health in Sudan. Smoke: the Killer in the Kitchen Indoor, Air Pollution in Developing Countries. Rugby, UK.

[33] Ibid

[34] United Nations Framework Convention on Climate Change and the Kyoto Protocol to the UNFCCC. www.unfccc.de

[35] Hambleton, Anne. (1998).An Annotated Glossary of Commonly Used Climate Change Terms .The Center for Sustainable Development in the Americas. Washington DC.

[36] Klarer, Swisher, and Kolehmainen. (1999).Synthesis Study of the National AIJ/JI/CDM Strategy Studies Program. World Bank, Swiss AIJ Pilot Program, and Ministry of Environment of Finland. Hesinki

[37] United Nations Framework Convention on Climate Change and the Kyoto Protocol to the UNFCCC. www.unfccc.de

[38] Bank of Uganda.(1993, June) Annual Report 1991/92. Kampala

[39] Government of Uganda.((2002, June). Background to the Budget for Financial Year 2004/05, Ministry of Finance Planning and Economic Development, pA12.

[40] Uganda Bureau of Statistics. ((2002, November). Household Survey 1999/2000.. p.10, Entebbe.

[41] Government of Uganda.((2003, June). Background to the Budget for Financial Year 2003/04, Ministry of Finance Planning and Economic Development, pA12.

[42] Uganda Bureau of Statistics. (2002, November). Statistical Abstract. p.49, Entebbe.

[43] Government of Uganda.((2003, June). Background to the Budget for Financial Year 2003/04, Ministry of Finance Planning and Economic Development, Kampala, pA12.

[44] Ministry of Finance and Economic Development .(1997).Human Development Report.

[45] Government of Uganda.(1997, June). Background to the Budget for Financial Year 1996/97, Ministry of Finance Planning and Economic Development. Kampala

[46] Bank of Uganda. (1995, June). Annul Report 1994/95.

[47] World Bank. (2001). World Development Indicators, Washington ,DC, p 200.

[48] Department of Statistic. (1998,December). Index of Industrial Production: Statistic Bulletin No IP/43, Ministry of Planning and Economic Development, Kampala.

[49] Uganda Bureau of Statistics.. (2000, June) . Statistical Abstract 2000. Entebbe.

[50] Government of Uganda.(2003, June). Background to the Budget for Financial Year 2003/04, Ministry of Finance Planning and Economic Development, Kamapala, p A58.

[51] Ministry of Finance Planning and Economic Development. (1999, February). A Strategic Framework for National Development Main Document (Working Draft), For National Dialogue, Vol. I, Kampala, p 105.

[52] Anil Markadya and Kirsten Halsnaes. (2002). Climate Change and Sustainable Development, Earth Scan Publication, London, p 27..

[53] Les Editions du Fleuve .(1987), Sustainable Development, Paris, , p. 51.

[54] Myung-Kyoon Lee. (2004, June). UNEP, CDM information and Guidebook Second Edition, Roskilde, Denmark, p 17..

[55] Definitions of Sustainable development on the Web:www.rff.org/glossary.htm.

[56] Definitions of Sustainable development on the Web: www.nps.gov/miss/info/cmp/glossary.html.

[57] Definitions of Sustainable development on the Web: www.prod.novonordisk.com/old/press/environmental/er98/intro/glossary.html

[58] Definition of sustainable development on web: www.census.gov/ipc/www/wp96glos.html.

[59] Emily Ojoo-Massawa,(2005, March 3). Report of the African Clean Development Mechanism, (Unpublished Report), Kampala, p.4.

[60] Thomas B, Jose G.(2002). Energy for Sustainable Development, A policy Action Agenda, UNDP, New York .

[61] Oscar Kibazohi. (2005, March 3).). Report of the African Clean Development Mechanism, (Unpublished Report) Kampala, p.4. .

[62] Eric Mukasa. (2005, March 3).). Report of the African Clean Development Mechanism, (Unpublished Report). Kampala, p.6.

[63] Anil Markadya and Kirsten Halsnaes.(2002). Climate Change and Sustainable Development, Earth Scan Publication, London, p 31.

[64] Forest Department. (1992, January). The National Biomass Study., Uganda Technical Report Phase I, Ministry of Water, Land and Environment, Kampala.

[65] Ibid p12.

[66] Forestry Department.(June 1996). Study of Woody Biomass Derived Energy Supplies in Uganda. Ministry of Water, Lands and Environment, , Kampala, p V1.

[67] Ibid

[68] Ibid p 5

[69] Ibid p5

[70] Ibid p5

[71] Forest Department, September. (2002, September). National Biomass Study: Technical Report. Ministry of Water Lands and Environment, Kampala, p.57

[72] Ibid

[73] Ibid

[74] Ibid

[75] Government of Uganda.(1987, June). Background to the Budget for Financial Year 1986/87, Ministry of Finance Planning and Economic Development. Kampala

[76] UNDP /World Bank. (1986). Bank Energy Sector Management Assistance Programme. Washington, DC.

[77] Ibid

[78] Forest Department, September. (2002, September). National Biomass Study: Technical Report. Ministry of Water Lands and Environment, Kampala.

[79] Forest Department, (1996). ESD Biomass Energy Survey : Statistic Department, Ministry of Water, Lands and Environment, kampala, p. XVI.

[80] Uganda Bureau of Statistics .(2002, June).Statistical Abstract 2002. Entebbe, p 82.

[81] Forestry Department. (2001). Biomass Energy Demand Survey. Uganda Forestry Sector Co-ordinating Secretariat, Ministry of Water, Lands and Environment, Kampala.

[82] Forest Department.(2002, September)., National Biomass Study: Technical Report,. Ministry of Water, Lands and Environment, Kampala, p 74.

[82] Ibid

[84] Uganda Bureau of Statistics. (2002, June). Statistical Abstract 2000. Entebbe, Uganda.

[85] Forest Department.(2002, March). National Biomass Study: Draft Technical Report,. Ministry of Water, Lands and Environment, Kampala, p 3.

[86] Ibid p 45.

[87] CODA and Partners.(1990, September). Household Energy Survey: Household Energy Planning Programme. Ministry of Natural Resources, Kampala.

[88] Ibid.

[89] Ibid

[90] UNDP/World Bank..(1996, March). Uganda Energy Assessment: Energy Sector Assistance Programme. Washington, DC.

[91] Forest Department. (1996). Uganda Scenario 1995-2015 National Biomass Study. Kampala.

[92] Uganda Energy Assessment.(1996, March). Uganda Energy Assessment: Energy Sector Assistance Programme. Washington, DC.

[93] Forest Department (2002, September) National Biomass Study Technical Report, Ministry of Water Lands and Environment, Kampala.

[94] Energy for Sustainable Development ltd.(1995). A Study of Woody Biomass Derived Energy Supplies in Uganda. Ministry of Water Lands and Environment, Kampala, pXVI.

[95] Ibid.

[96] Ibid

[97] Ibid

[98] Ibid

[99] Ibid.

[100] Ibid , p VI

[101] Kgathi,D.L, Hall,D.O., Hategeka, A.,Sekhawela, M.B.M.,(eds). (1997). Biomass Energy Policy in Africa. African Energy Policy Research Network, ZED Books, London and New Jersey, p 4.

[102] Leach G and Mearns R.(1988). Beyond the Fuelwood Crisis. Earthscan Publication Limited, London, p2.

[103] Ibid

[104] .Ibid

[105] Ibid

[106] Ibid

[107] Bradley, P.N. (1991). Wood fuel, Women and Woodlots. The Foundations of a Woodfuel Development Strategy for East Africa, Macmillan, Vol 1,.London and Basingstoke, p 274.

[108] Ibid

[109] Ibid p 277

[110] Ibid p 12

[111] World Energy Council. (1988). Rural Energy in Developing Countries. Vol. 1, UK, p50.

[112] Ibid

[113] FOA. (1996). Pattern of wood supply, distribution and use in the city and province of Cebu [The Philippines] , FOPW, Rome.

[114] World Energy Council.(1998). Rural Energy in Developing Countries. Vol. 3, UK, p143

[115] World Energy Council.(1998). Rural Energy in Developing Countries. Vol. UK, 2, p9

[116] Ibid

[117] World Bank.(2005). World Development Indicators, Washington, D.C, p144.

[118]Poverty Reduction aspects of successful Improved Household Stoves Programme. (2001). http:// www.povertystoves.energy projects.net

[119] Ibid

[120] Ibid

[121] S.A.Baldwin. (1996). MSc. Thesis, The development of low cost fuel efficient wood burning stoves a appropriate to underdeveloped areas of South Africa, Energy Research Institute, University of Cape Town.

[122] J.A.N Graham.(1997,April). MSc. Thesis, Testing Efficiency of Domestic Stoves, Energy Research Institute, University of Cape Town.

[123] P.J. Turyareba, M.J.Kumani.(1992). Testing Efficiency of Cooking Stoves : A Manual for Africa. KENGO/The Regional Energy Programme for Africa (RWEPA). Nairobi

[124] CODA and Partners. (1990, September). Household Energy Survey. Household Energy Planning Programme. Ministry of Energy an Mineral Development, Kampala.

[125] Ibid p12

[126] Energy for Sustainable Development ltd (1996, July). A Study of Woody Biomass Derived Energy Supplies in Uganda, Department of Forestry, Ministry of Water, Lands and Environment, Kampala , p76.

[127] Rosillo - Calle et al.(1986). Biomass Energy use in Developing Countries. Commission of European Community.[Europe].

[128] Department of Energy. (1996). Lime Production in Tororo. Ministry of Natural Resources. Kampala.

[129] Ibid p1.

[130] Energy for Sustainable Development Ltd. (1986). A Study of Woody Biomass Derived Energy Supplies in Uganda, Forestry Department, Ministry of Natural Resourses, p 76.

[131] Department of Energy. (1996). Lime Production in Tororo. Ministry of Natural Resources. Kampala, p 10,.

[132] Department of Energy. (1996). Commercial Wood Application: Lime Industry. Ministry of Natural Resources ,Kampala, Unpublished Report, p12.

[133] Jacovelli&Calvalho.(20001, April).Voices from the field, Review of Forestry Initiative in Uganda, Synthesis report Vol. 1.Kampala, p.50.

[134] Energy for Sustainable Development Ltd. (1996). A Study of Woody Biomass Derived Energy Supplies in Uganda. p 80.Kampala.

[135] Ibid, p 81.

[136] Ibid

[137] UNDP/World Bank.(1996, March). Uganda Energy Assessment. Energy Sector Assistance Programme , Washington, DC ,p 62..

[138] Energy for Sustainable Development Ltd (1996). A Study of Woody Biomass Derived Energy Supplies in Uganda Ministry of Natural Resources, p82.

[139] UNDP/World Bank.(1996, March). Uganda Energy Assessment .Energy Sector Assistance Programme, p 62.

[140] Energy for Sustainable Development ltd (1996). A Study of Woody Biomass Derived Energy Supplies in Uganda. Ministry of Natural Resources, p84.

[141] Energy for Sustainable Development Ltd (1992). The National Biomass Study, Uganda Technical Report Phase I,p57. Ministry of Natural Resources.

[142] Ibid

[143] Ibid p58

[144] Ibid p57

[145] Ibid. p58

[146] Ibid

[147] Ibid p58

[148] Ibid p57

[149] Ibid p59

[150] ESD (1996, September). Study of Woody Biomass Derived Supplies in Uganda: Consumption and Biomass Sustainable Harvest p 59.

[151] Ibid p 60.

[152] CODA and Partners (1990, September). Household Energy Survey: Household Energy Planning Programme, Priston New Jersy.

[153] Jacovelli&Calvalho.(20001, April).Voices from the field, Review of Forestry Initiative in Uganda, Synthesis report Vol.1, p.78.

[154] Forest Department,(1992).The National Biomass Study Uganda Technical Report, Phase I, p 65.

[155] Energy for Sustainable Development Ltd. (1996, September). Study of Woody Biomass Derived Supplies in Uganda: Consumption and Biomass Sustainable Harvest p 68.

[156] Ibid p 68b

[157] Ibid p V

[158] Ibid p 67

[159] Ibid p 16

[160] Ibid p 68

[161] Ibid p 69

[162] Ibid p 71

[163] Forest Department .(1992).The National Biomass Study Uganda Technical Report Phase I.

[164] UNDP/World Bank.(1996, March). Uganda Energy assessment. Energy Sector Management Assistance Programme, Uganda Energy Assessment, annex 2.

[165] Ibid, p 58.

[166] Ibid, Annex 2.4.

[167] Ibid, p 4.

[168] Uganda Bureau of Statistics.(2001,June). Statistical Abstract 2001, p 77.

[169] Patience Turyareba, Drichi Paul.(2001, November). Plan for development of Uganda Biomass Energy Development, p14.

[170].Government of Uganda (1991). Farming Systems Programme : Ministry of Agriculture, Animal Industry and Fisheries, Kampala.

[171] Government of Uganda (1988). Uganda National Energy Development Organisation. Report, Ministry of Natural Resources, Kampala. .

[172] Department of Energy.(2000, February). Rural Household Energy Programme Ministry of Energy and Mineral Development, Kampala, p16.

[173] World Bank .(2000, January). Uganda: Energy for Rural Transformation AFRRIE Mission : Draft Aide Memoire, Washington, DC.

[174] UNDP &World Bank. (1999 , January). Rural Electrification Strategy Study. Energy Sector Management Assistance Programme, Washington, DC.

[175] Department of Energy . (2000, February).Uganda Household Energy Status Report Ministry of Energy and Mineral Development, Kampala, p 15.

[176] UNDP &World Bank.(1996, March). Uganda Energy Assessment .Energy Sector Management Assistance Programme, p 4.

[177] Department of Energy .(2003, April).Over view of Uganda Energy .Ministry of Energy and Mineral Development.

[178] Government of Uganda. (1997, October) Strategic Plan for Uganda Power Sector .Ministry of Natural Resources, Kampala, p16.

[179] UNDP &World Bank.(1999, January).Uganda Rural Electrification Study, Energy Sector Management Assistance Programme p15.

[180] Uganda Electricity Board. (1999, June). Key Monitoring Statistics 1990-1998.

[181] Nordic Consulting Group. (1999, October).Review of the Norwegian Input to the Energy Sector in Uganda. Ministry of Energy and Mineral Development, Kampala.

[182] UNDP &World Bank. (1999, January).Uganda Rural Electrification Strategy Study. Energy Sector Assessment Program, Washington, DC.p17.

[183] Ibid p15.

[184] The Government of Uganda .(2002, September).The Energy Policy for Uganda. Ministry of Energy and Mineral Development,. Kampala, p15.

[185] Electricity Regulatory Authority, 2005 April 11, The New Vision, p 18.

[186] Nordic Consulting Group. (1999, October).Review of the Norwegian Input to the Energy Sector in Uganda , Ministry of Energy and Mineral Development.

[187] Electricite de France.(1998). Optimisation Study Load Forecast. Uganda Electricity Board.,Kampala.

[188] Kennedy and Donkins.(1997). Hydro Power Master Plan. Uganda Electricity Board, Kampala.

[189] Acres International.(1997). Electricity Load Forecast. Uganda Electricity Board, Kampala.

[190] UNDP & World Bank.(1999). Energy Sector Assessment Program.

[191] UNDP & World Bank. (1999, January).Uganda Rural Electrification Strategy Study. Energy Sector Assessment Program, p16.

[192] Uganda Government. (2002, September).The Energy Policy for Uganda. Ministry of Energy and Mineral Development, p 15

[193] Ibid, p47

[194] Uganda Electricity Board. . (2001). Monthly monitoring parameters, January–December 2000 , Kampala

[195] Bujagali still on (2002, June 7). New Vision , p 35.

[196] World Bank report slams Bujagali dam .(2002, June 12). The Monitor, No 163, 2002.

[197] Bujagali Power to Cost Twice World Average. (2002,June 17-20) *The East African,* p 32.

[198] Njeri Wamukonya.(2003). Electricity Reform, Social and Environmental Challenges, UNEP, p128. Roskilde, Denmark

[199] ERA nod three to supply power. (2002, August 7). New Vision, p 43.

[200] Department of Energy.(2000, February). Uganda Household Energy Status Report Ministry of Energy and Mineral Development, p11.

[201] Uganda Electricity Distribution Company Ltd. (2001). Key Monitoring Statistics1992-2000

[202] Ibid

[203] UNDP & World Bank.(1996, March). Uganda Energy Assessment. Energy Sector Assistance Programme.

[204] Voravate, Tig, Tuntivate.(1997). Uganda Non Grid Rural Electrification Analysis of Households Energy Demand Survey. Ministry of Energy and Mineral Development, p22.

[205] World Bank. (2000, January) Uganda: Energy for Rural Transformation, AFRRIE Mission : Draft Aide Memoire.

[206] Khalema-Rebeby. et al.(1998). Planning and Management in the African Power Sector. African Energy Policy Research Network, Zed Books, London .p11

[207],Ibid, p13

[208] Ibid,13-14 pp.

[209] Ibid,p227

[210] World Bank (1993) World Bank Policy Paper.: Energy Efficiency and Conservation in Developing World, p14. Washington, DC.

[211] Bereket Kebede and Ikhupuleng Dube.(2004). Energy Services for the Urban Poor. African Energy Policy Research Network, ZED BOOKS,. London and New Jersey, p 239.

[212] Electricity Regulatory Authority.(2005, April 11) The New Vision, p 18

[213] High Power Tariffs Threaten Industries. (2005, April 12).New Vision , p5

[214] Ibid

[215] Ibid

[216] Petroleum exploration and Production Department. (1997).The Hydrocarbon Potential of the Albertine Graben.. Ministry of Energy and Mineral development, Kampala, p3.

[217]Ibid, p23.

[218] Ministry of Energy and Mineral Development.(2002). Annual Report 2002, p24

[219] Government of Uganda .(2002, September).The Energy Policy for Uganda. Ministry of Energy and Mineral Development, p17.

[220] Ibid

[221] Uganda Bureau of Statistics.(2000, July) Statistical Abstract,

[222] UNDP & World Bank .(1996, March) Uganda: Energy Assessment. Energy Sector Assistance Programme p 9.

[223].Governmment of Uganda.(2000, June) The National Energy Balance 1999, Ministry of Energy and Mineral Development, Kampala.

[224] Hilma R.Zeissing.(2000, June). Analysis and Proposed Reform of the Regulatory Framework for Down Stream Petroleum Market in Uganda .Kampala.

[225] Department of Energy. (2003, April) Overview of Uganda Energy Situation, Ministry of Energy and Mineral Development, Kampala. Unpublished report.,

[226] Hilma R.Zeissing.(2000, June) Analysis and Proposed Reform of the Regulatory Framework for Down Stream Petroleum Market in Uganda, Kampala.

[227] Petrol Prices Increase. (2002, August 2) New Vision p21.

[228] Voravate, Tig, Tuntivate.(1997). Uganda Non grid Rural Electrification:Analysis of household Energy Demand Survey. Ministry of Energy and Mineral Development,

[229] Ibid.

[230] Ibid.

[231] Ibid

[232] Ibid

[233] Godfrey .R. Turyahikayo . (1994) Status of Renewable Energy Technologies Dissemination in Uganda. AFREPREN Working Paper 30 . Nairobi.

[234] Solarex Corporation.(1992), World Design Insolation. New York.

[235] Department of Energy. (2001, March).Alternative Energy Resource Development Programme. Ministry of Energy and Mineral Development, p6.

[236] Department of Energy. (2003, September).Alternative Energy Resource Development Programme, Final Report. Ministry of Energy and Mineral Development, p7.

[237] Hans C, Jung H,.(2001, October). Solar Pumping in Uganda, Drinking water for community: Renewable ENERGY World September/ October 2001. London, p 109.

[238] Ibid, p 110.

[239] Ibid, p 111.

[240] Uganda Government.(1997). UPPPRE, Project Document No UGA/97/G32/A/IG/99, Ministry of Natural Resources, Kampala.

[241] World Bank.(2001, February).Energy for Rural Transformation Project , Project Appraisal Document. .Washington, DC.

[242] Energy for Sustainable Development Ltd. (1995, June).A Review of Renewable Energy Resources and Technologies in Uganda, Final Report. World Bank IENPD, Washington DC.

[243] Rodolfo, Pallabazza & Adam, M.Sebbit.(1998). Data Bank: The Wind resources for Uganda, Pergamon Press , Renewable Energy Vol. 13. Elsevier Science, pp.41-49,

[244] Ibid

[245] Energy for Sustainable Development Ltd. (1998, September) Accelerating rural electrification through East African Small Scale Enterprises Co-operation. Ministry of Energy and Mineral Development. Kampala..

[246] Energy Department. (2001, September).Alternative Energy Resource Development Programme, Report. Ministry of Energy and Mineral Development, kampala, p6.

[247] UNDP/World Bank.(1996, March). Uganda Energy Assessment. Energy Sector Assistance Programme , Washington DC, p20.

[248] H.W.O., Okoth-Ogendo & J.B.Ojwang .(1995). A climate for Development , Climate Change Policy Options for Africa. Stockholm Environment Institute, Stockholm

[249] Arnaldo, Walter & Luis, Cortez .(1999,July). An Historical Review of the Brazilian Bioethanol Program, Renewable Energy for Development Environment Institute, Vol. 11 No.1, Stockholm

[250] UNDP & World Bank.(1983) Uganda: Issues and Options in Energy Sector. ESMAP. Washington, DC.

[251] Technology Consult. (1992). Strengthening of Endogenous Capacity in Science and Technology Through National policy Dialogues. Project: INT/OT2-UNDP/OpS. Theme 3: Energy sector identification of alternative forms of energy including new and renewable that can be used to limit the impact on environment. Ministry of Natural Resources, Kampala.

[252] Department of Energy. (2001, September).Alternative Energy Resource Development Programme, Report. Ministry of Energy and Mineral Development,

[253] Department of Petroleum Exploration and Production .(1991).Drilling for Geothermal Energy. Ministry of Natural Resources . Entebbe, Uganda.

[254] Econo Oy .(2001, March). Alternative Energy Resource Development Programme, Ministry of Energy and Mineral Development, Kampala, p6.

[255] Peter Colley.(1997) Reforming Energy. Pluto Press p45

[256] United Nations Environment Programme.(2002).Africa Environment Outlook. Policy and Action Recommendations for a Sustainable Development Nairobi, p2.

[257] Jonhanson, T.B, & Goldemberg, J. (2002). Energy for Sustainable Development: UNDP New York, p4.

[258] Ibid, p11

[259] Uganda Government.(2002, October).Uganda National Communication to the United Nations Framework Convection on Climate Change. Ministry of Water, Lands and Environment. Kampala.

[260] World Bank .(2002). Prototype Carbon Fund Annual Report. Washington, DC

[261] National Environment Management Authority. (1998).State of Environment Report for Uganda. Kampala.

[262] World Health Organization. (1997). Health and environment in sustainable development: five years after the Earth Summit. Geneva

[263] Bruce, N., Perez . Paddila R, Alablak R. (2000). Indoor air pollution in Developing Countries a Major Environmental and Public Health Challenge: World Health Organisation, Bulletin 2000 78: 1078-1073. Geneva

[264] Dewan, A. (1998, September). Occupational and Environmental Health of Women, Paper presented at the UN Expert Group Meeting on Women and Health- Mainstreaming the Gender Perspective into the Health Sector. Tunis, Tunisia.

[265] Winrock International consultant . (2005, February).Partnership for Clean Indoor Air.

[266] Partnership for Clean Indoor Air. (2004, November 18) http://www.epa.gov/iaq/pcia.html

[267] Department of Energy.(2004). How to build improved household stoves. Ministry of Energy and Mineral Development. Kampala

[268] Jivan .E (2005) Scaling up and Commercialisation of Household Energy Initiatives, ITDG, Boiling Point Number 50. Rugby, UK

[269] Intermediate Technology Group (2005, February). Boiling Point, Scaling up and commercialisation of household Energy Initiatives, number 50.2005.

[270] World Health Organisation. (2000). Addressing the Link between Indoor Air Pollution Household Energy and Human Health Geneva

[271] IPCC. (1996). Revised Guidelines for National Greenhouse Gas Inventory: Workbook Volume 2,.

[272] United Nation Development Program /Department of Economic and Social Affair. /World Energy Council/ World Energy Assessment. (2005, January) http://www.itdg.org/?id=iap_who.

[273] Nigel Bruse. (2001). Kenya Smoke and Health Project 1998-2001.: Intermediate Technology Development Group: Practical Answers to Poverty.

[274] Schirnding et al .(2002). Addressing the Impact Household Energy and Indoor Air Pollution on Health of the Poor, World Health Organisation. Geneva

[275] Ibid

[276] The Government of Uganda. (2002, September).The Energy Policy for Uganda.. Ministry of Energy and Mineral Development.

[277] Ibid, p9.

[278] The Government of Uganda. (1999). Electricity Act.1999. Ministry of Energy and Mineral Development. Kampala.

[279] The Government of Uganda. (2002, September). The Energy Policy for Uganda. Ministry of Energy and Mineral Development, p 13.

[280] Ibid , p 17.

[281]Ibid, p 22.

[282] Maxime Kleinpeter.(1995). Energy Planning and Policy. John Wiley and Sons, London, p176.

[283] Ibid ,p178.

[284] Bunn, D.W, & Larsen E.R .(1997). Systems modelling for energy policy, John Wiley and Sons, p2.

[285] Maxime Kleinpeter.(1995).Energy Planning and Policy. John Wiley and Sons, London, p 276-280.

[286] Ibid, p 298-299

[287] Ibid, p335

[288] Auther, Anton. (1994) International Experience in Energy Policy Research and Planning,.: Elan Press, Macedon NY. p25-27

[289] Bunn, D.W, & Larsen E.R. (1997). System modelling for Energy Policy. John Wiley and Sons. Ltd.: Chichester, UK, P 90.

[290] Ibid, Page 91

[191] Ibid, Page 91

[292]UNDP & World Bank. (1996 March.) ,Uganda Energy Assessment. Energy Sector Management Assistance Programme, Washington, D.C.

[293] Electricity de France. (1998, September). Optimisation Study, Load Forecast. Uganda Electricity Board. Kampala

[294] Electricity de France (1998, September). Optimisation Study Load Forecast: PVD SOFTWARE Version 3.0 for Windows, Users Guide. Paris

[295] Patience, J. T & Muiruri J.K.(1992). Testing the efficiency of stoves, Adapted from the revised VITA-1985- Regional Wood Energy Programme for Africa. Nairobi.

[296] Government of Uganda. (2000, June). National Energy Balance. Ministry of Energy and Mineral Development.

[297] Forest Department. (1992, September) National Biomass Study Technical Report, Ministry of Water, Lands and Environment, Kampala. p 61.

[298] CODA and Partners.(1990). Household Energy Survey. Household Energy Planning Programme. Kampala.

[299] Uganda Electricity Distribution Company. (2000, June). Monitoring Statistics, 2000.

[300] Government of Uganda. (2001, June). Background to the Budget 2001/02, Appendix A6. Ministry of Finance and Economic Development. Kampala.

[301] Government of Uganda.(2001, June). Background to the Budget 2001/02, Appendix A38. Ministry of Finance and Economic Development

[302] Government of Uganda. (2000, June). National Energy Balance. Ministry of Energy and Mineral Development.

[303] Ibid

[304] Ibid

[305] Ibid

[306] Ibid

[307] Uganda Electricity Distribution Company. (2000, June). Monitoring Statistics, 2000.

[308] Ibid

[309]The Government of Uganda. (2000, June).Background to the Budget for the financial year 2001/02, Ministry of Finance, Planning and Economic Development. Kampala.

310 The Energy Research Institute.(2000). Indian Cement Industry. (Unpublished) Bangolow, India

311 UNIDO & Sustainable Industrial Development.(2001,August).Energy Conservation in Cement Industry: Production process in cement industry.

http://www.unido.org/ssites/env/sectors/sectorscement02.html.

312 The Energy Research Institute.(2000). Indian Cement Industry. (Unpublished) Bangalo, India

313 Madhavani Power : Cogeneration Madhavani Quarterly In-house Magazine Vol. 6 No.4 Quarterly In-house Magazine Oct-Dec 1999.

314 Uganda Bureau of Statistics .(2001, June) 2001 Statistical Abstract p83.

315 Joyce & Burgi.(1993). Cleaner Production Assessment in Dairy Industry. Australian Diary Processors.

316 Heineken Breweries.(2000). Environment Report 2000. The Netherlands.

317 Carlsberg Breweries.(2000). Environmental Report 1998-2000. Copenhagen, Denmark.

318 The Government of Uganda . (2001,June). Background to the Budget for the Year 2001/2002 ,p.A40. Ministry of Finance Planning and Economic Development.

319 Ibid, A40.

320 Ibid,A41.

321 Ibid ,A51.

322 Department of Energy.(2001,August). Lime Model at Busanza. (Unpublished report) Ministry of Energy and Mineral Development.

323 H., Giest.(1997) How Tobacco Contributes to Tropical Deforestation: Wood use Statistics of African Tobacco 1986-1997. Utrech.

324 Tata Energy Research Institute. (1999). Resource Utilisation Improvement in Bricks Industry, Case study, New Delhi.

325 Ibid

326 Government of Uganda. (2001,June). Background to the Budget for the Year 2001/2002. Ministry of Planning and Economic Development, Kampala, p.6

327 Government of Uganda .(2001,June). Background to the Budget for the Year 2001/2002_. Ministry of Planning and Economic Development. Kampala. p.9

[328] Asian Institute of Technology. (2000) Energy use and Pollution in the Tea Industry, Small Scale Industry News letter, July-September, Volume 2 No.3. Sri Lanka

[329] Energy for Sustainable Development (1996, July). A study of Woody Biomass Derived Energy Supplies in Uganda, Page 76 Minister of Natural Resources. Kampala.

[330] Uganda Electricity Board. (2000,June). Monitoring Statistics (1990-1999),

[331],Uganda Bureau of Statistics (2001, June) Statistical Abstract 2001. Entebbe, p59.

[332] Ibid p66.,

[333] Ministry of Education.(2000, June). Education Statistical Abstract 2000, Ministry of Education and Sports. Kampala.

[334] National Energy Balance.(2001, June).Ministry of Energy and Mineral Development. Kampala.

[335] Uganda Investment Authority.(2001, June). Investing in Uganda, UIA. Kampala, Uganda, p3.

[336] Government of Uganda (2002, June).Background to the budget for the year 2002/03. Ministry of Finance, Planning and Economic Development, Kampala ,pA8.

[337] The Government of Uganda.(2002, October).Uganda Initial National Communication to the United Nations Framework Convection on Climate Change, p21 Ministry of Lands Water and Environment. Kampala.

[228] Uganda Bureau of Statistics (2000, June). 2000 Statistical Abstract. p103.

[339] Uganda Railway Corporation.(1999,October).Uganda Railway Corporation at a Glance Today. URC, Kampala,.p.3.

[340] Uganda Railway Corporation.(2001, June). Bureau of Statistics, and Statistics Section, .Ministry of Housing Transport and Communication. Kampala, Uganda. p107

[341] Government of Uganda (20001, June)The Background to the budget for the year 2001/02.2001, Ministry of Finance, Planning and Economic Development. Kampla, p57.

[342] Uganda Railways cooperation, to be privised. (2002, June 17-23) .The East African newspaper p.17.

[343] Petroleum Department.(2001, June).Petroleum Products Consumption. Ministry of Energy and Mineral Development, Kampala.

[344] Government of Uganda.(1998, December) .Vision 2025, A strategic Framework for National Development. Ministry of Finance, Planning and Economic Development, Kampala.

[345] Seale R.L. and Sierka R.A.(1973). Energy Needs and the Environment. 1998-1001 pp, University of Arizona Press

[346] UNDP&World Bank.(1983, July).Uganda: Issues and Options in the Energy Sector. Energy Sector Assessment Program, Washington, D.C.

[347] EDF. (1998, September) .Optimisation Study Load Forecast, PVD SOFTWARE Version 3.0 for Windows: Users Guide.

[348] Ministry of Energy and Mineral Development.(2001, June) Annual Report 2001. p 26.

[349] World Bank. (2003).World Development Indicators.. Washington, D.C, pp 187-188

[350] Ibid, p188.

[351] World Bank.(2001) World Development Report 2000/2001,. Washington, D.C. pp. 274-276

[352] UNDP. (2004). Human Development Report 2004,. New York. p 186

[353] The Government of Uganda . (2001,June). Background to the Budget for the Year 2001/2002. Ministry of Planning and Economic Development, Kampala. p.A3

[354] Mubiru, P., (2003,May). Efficient Utilisation of Energy Resources, 8th.Natioanl Conference, Ministry of Energy and Mineral Development, May 2003.

[355] http://www.nationmaster.com/country/Energy

[356] Government of Uganda. (2001, June). Background to the Budget for the Year 2001/2002 ,. Ministry of Planning and Economic Development, Kampala, p.A40.

[357] Government of Uganda. (2001,June). Background to the Budget for the Year 2001/2002 , Ministry of Finance, Planning and Economic Development. p.6

[358] World Bank.(2003).World Development Indicators, Washington D.C, pp 187-188.

[359] Ministry of Agriculture.(2000,June). Plan for Modernisation of Agriculture: Eradicating Poverty in Uganda, Ministry of Agriculture, Animal Industry and Fisheries.

[360] World Bank.(2003).World Development Indicators, Washington D.C, p 250.

[361] World Bank .(2000). Selected World Development Indicators, Washington D.C, p 296 – 297.

[362] The Government of Uganda. (2001, June). Background to the Budget for the Year 2001/2002 , Ministry of Finance, Planning and Economic Development . p.A8.

[363] Ibid, p.A12

[364] Uganda Bureau of statistics. (2001 June). Statistical Abstract 2000, p19

[365] .The population of Uganda to hit 35 million by 2115 . (2003, January,12) New Vision January p 16.

[366] Uganda Bureau of Statistics.(2002, November). Population and Housing Census, Preliminary Report, . Entebbe, p5

[367] The Government of Uganda. (2001,June). Background to the Budget for the Year 2001/2002. Ministry of Planning and Economic Development. p44.

[368] Uganda's Economy Hard Hit by Aids.(2002, December 9-15)., East African Newspaper. p 32.

[369] Investment Survey. (2000). Uganda Investment Authority, Kampala, p 1.

[370] Ibid, p 31

[371] Ibid,p21

[372] Ibid, p 32

[373] Ibid, p 50-51

[374] Next general election will be held in 2006. (2005, March 25). New Vision, p1.

[375] America against 3rd term. (2005, 30th March). New Vision, p1.

[376] World Bank. (2001). Development Report 2000/2001, Washington D.C, p 34.

[377] African Review. (2001, August).Uganda Economy, London p 14.

[378] Uganda Bureau of Statistics.(2001,June).Uganda National Household Survey 1999/2000,

[379] African Review .(2001, August).Uganda, Building on stable base, p 15

[380] Ibid, p 14

[281] United States civil liberties NGO Freedom House. (2001). World Report 2000-2001..

[382] Government of Uganda .(2003,June). Background to the Budget for the Year 2003/2004 , Ministry of Planning and Economic Development, pA25.

[383] Global Links.(2001). Selected World Development Indicators, Washington, DC. p 315.

[384] World Bank.(2005). Global Development Finance, Washington, D.C, p544.

[385] Uganda debt relieve equals US$ 3.8dollars. (2004, June 14) Daily Monitor, p2.

[386] Government of Uganda. (2001,June). Background to the Budget for the Year 2001/2002 , Ministry of Planning and Economic Development. p44.

[387] World Bank. (2001).Selected World Development Indicators ,Washington D.C, p 307.

[388] African Reviews. (2001, August).Uganda, Building on stable base, p 15.

[389] Uganda Bureau of Statistics. (1999, July). Statistical Abstract, 1999., Entebbe. p 32

[390] Government of Uganda.(1998, December). Vision 2025: A strategic Framework for National Development, Ministry of Finance, Planning and Economic Development.

[391] Uganda Bureau of Statistics .(2001, June). Statistical Abstract 2001. p.86

[392] Government of Uganda. (1999, June). Background to the Budget for the Year 1999/2000 Ministry of Planning and Economic Development. ,p A8.

[393] Government of Uganda.(1999, December). Vision 2025: A strategic Framework for National Development Ministry of Finance, Planning and Economic Development, , p 64.

[394] Government of Uganda.(1998, December). Vision 2025: A strategic Framework for National Development. Ministry of Finance, Planning and Economic Development, , p169

[395] Ministry of Energy and Mineral Development (2003, April). Uganda Energy Balance 2002. Kampala

[396] UNDP & World Bank.(1996, March). Uganda Energy Assessment. Energy Sector Management Assistance Programme. Washington. D.C.

[397] Uganda Electricity Board.(2000).Monitoring Statistics (1990-1999).

[398]. Forest Department (2003, November). National Biomass Study., p 105 Ministry of Water, Land and Environment,.

[399] Forest Department (2002, September). National Biomass Study. Ministry of Water, Land and Environment, p 91.

[400] Ibid ,p 48.

[401] Forest Department (2003, November). National Biomass Study. Ministry of Water, Land and Environment, p 63.

[402] Ministry of Energy and Mineral Development. (2000). Rural Electrification Strategy and Plan (2001-2010), Kampala, Uganda.

[403] World Bank.(2000). Prototype Carbon Fund, Washington, D.C.

[404] Uganda Railway Corporation. (2002, December). Transaction Advisory Services, Due Diligence Report Vol.1. Kampala.

BIBLIOGRAPHY

Acres International. (1997). Electricity Load Forecast. Uganda Electricity Board, Kampala.

African Reviews. (2001, August).Uganda, Building on stable base. London.

African Review. (2001, August).Uganda Economy, London.

AFRRIE Mission : Draft Aide Memoire, Washington, DC.

Anil Markadya and Kirsten Halsnaes. (2002). Climate Change and Sustainable Development, Earth Scan Publication, London.

Arnaldo, Walter & Luis, Cortez .(1999,July). An Historical Review of the Brazilian Bioethanol Program, Renewable Energy for Development Environment Institute, Vol. 11 No.1, Stockholm.

Auther, Anton. (1994) International Experience in Energy Policy Research and Planning,.: Elan Press, Macedon.

Asian Institute of Technology. (2000) Energy use and Pollution in the Tea Industry, Small Scale Industry News letter, July-September, Volume 2 No.3. Sri Lanka.

Baldwin, s, A, (996) MSc. Thesis, The development of low cost fuel efficient wood burning stoves a appropriate to underdeveloped areas of South Africa, Energy Research Institute, University of Cape Town.

Bank of Uganda.(1993, June) Annual Report 1991/92. Kampala

Bank of Uganda. (1995, June). Annul Report 1994/95.

Bereket Kebede and Ikhupuleng Dube.(2004). Energy Services for the Urban Poor. African Energy Policy Research Network, Zed Books. London.

Bradley, P.N. (1991). Wood fuel, Women and Woodlots. The Foundations of a Woodfuel Development Strategy for East Africa, Macmillan, Vol 1. London.

Bruce, N., Perez . Paddila R, Alablak R. (2000). Indoor air pollution in Developing Countries a Major Environmental and Public Health Challenge: World Health Organisation, Bulletin 2000 78: 1078-1073. Geneva.

Bunn, D.W, & Larsen E.R .(1997). Systems modeling for energy policy, John Wiley and Sons.

Carlsberg Breweries.(2000). Environmental Report 1998-2000. Copenhagen, Denmark.

CODA and Partners. (1990, September). Household Energy Survey: Household Energy Planning Programme. Ministry of Natural Resources, Kampala.

CODA and Partners (1990, September). Household Energy Survey: Household Energy Planning Programme. Priston New Jersey.
Cogeneration Madhavani Quarterly In-house Magazine Vol. 6 No.4 Oct-Dec 1999.

Daily Monitor News paper.

Dewan, A. (1998, September). Occupational and Environmental Health of Women, Paper presented at the UN Expert Group Meeting on Women and Health- Mainstreaming the Gender Perspective into the Health Sector. Tunis, Tunisia.

Department of Energy.(2001,August). Lime Model at Busanza. (Unpublished report) Ministry of Energy and Mineral Development.

Department of Energy. (2001, September).Alternative Energy Resource Development Programme, Report. Ministry of Energy and Mineral Development,

Department of Petroleum Exploration and Production .(1991).Drilling for Geothermal Energy. Ministry of Natural Resources . Entebbe, Uganda.

Department of Statistic. (1998,December). Index of Industrial Production: Statistic Bulletin No IP/43, Ministry of Planning and Economic Development, Kampala.

Definitions of Sustainable development on the Web:www.rff.org/glossary.htm.

Definitions of Sustainable development on the Web: www.nps.gov/miss/info/cmp/glossary.html.

Definitions of Sustainable development on the Web: www.prod.novonordisk.com/old/press/environmental/er98/intro/glossary.html

Definition of sustainable development on web: www.census.gov/ipc/www/wp96glos.html.

Department of Energy. (1996). Lime Production in Tororo. Ministry of Natural Resources. Kampala.

Department of Energy. (1996). Commercial Wood Application: Lime Industry. Ministry of Natural Resources ,Kampala, Unpublished Report.

Department of Energy.(2000, February). Rural Household Energy Programme Ministry of Energy and Mineral Development, Kampala.

Department of Energy . (2000, February).Uganda Household Energy Status Report Ministry of Energy and Mineral Development, Kampala.

Department of Energy. (2003, April) Overview of Uganda Energy Situation, Ministry of Energy and Mineral Development, Kampala. Unpublished report.

Electricite de France.(1998). Optimisation Study Load Forecast. Uganda Electricity Board. Kampala.

Electricity de France (1998, September). Optimisation Study Load Forecast: PVD SOFTWARE Version 3.0 for Windows, Users Guide. Paris

Emily Ojoo-Massawa,(2005, March 3). Report of the African Clean Development Mechanism, (Unpublished Report), Kampala.

Energy for Sustainable Development ltd.(1995). A Study of Woody Biomass Derived Energy Supplies in Uganda. Ministry of Water Lands and Environment, Kampala.

EDF. (1998, September) .Optimisation Study Load Forecast, PVD SOFTWARE Version 3.0 for Windows: Users Guide.

Energy for Sustainable Development Ltd. (1986). A Study of Woody Biomass Derived Energy Supplies in Uganda, Forestry Department, Ministry of Natural Resourses.

Energy for Sustainable Development ltd (1996, July). A Study of Woody Biomass Derived Energy Supplies in Uganda, Department of Forestry, Ministry of Water, Lands and Environment, Kampala.

Energy for Sustainable Development Ltd. (1992). The National Biomass Study, Uganda Technical Report . Ministry of Natural Resources, Kampala.

Energy for Sustainable Development Ltd. (1996, September). Study of Woody Biomass Derived Supplies in Uganda: Consumption and Biomass Sustainable Harvest. Ministry of Natural Resources. Kampala.

Energy for Sustainable Development Ltd. (1995, June).A Review of Renewable Energy Resources and Technologies in Uganda, Final Report. World Bank IENPD, Washington DC.

Energy for Sustainable Development Ltd. (1998, September) Accelerating rural electrification through East African Small Scale Enterprises Co-operation. Ministry of Energy and Mineral Development. Kampala..

Energy for Sustainable Development (1996, July). A study of Woody Biomass Derived Energy Supplies in Uganda, Page 76 Minister of Natural Resources. Kampala.

Energy Department. (2001, September).Alternative Energy Resource Development Programme, Report. Ministry of Energy and Mineral Development, Kampala.

Energy Research Institute.(2000). Indian Cement Industry. (Unpublished) Bangolow, India

Eric Mukasa. (2005, March 3).). Report of the African Clean Development Mechanism, (Unpublished Report). Kampala.

FOA. (1996). Pattern of wood supply, distribution and use in the city and province of Cebu [The Philippines] , FOPW, Rome.

Forest Department. (1992, January). The National Biomass Study., Uganda Technical Report Phase I, Ministry of Water, Land and Environment, Kampala.

Forest Department. (2002,September). National Biomass Study: Technical Report. Ministry of Water Lands and Environment, Kampala.

Forestry Department.(June 1996). Study of Woody Biomass Derived Energy Supplies in Uganda. Ministry of Water, Lands and Environment, , Kampala.

Forest Department, September. (2002, September). National Biomass Study: Technical Report. Ministry of Water Lands and Environment, Kampala.

Forest Department, September. (2002, September). National Biomass Study: Technical Report. Ministry of Water Lands and Environment, Kampala.

Forest Department, (1996). ESD Biomass Energy Survey : Statistic Department, Ministry of Water, Lands and Environment, kampala.

Forestry Department. (2001). Biomass Energy Demand Survey. Uganda Forestry Sector Co-ordinating Secretariat, Ministry of Water, Lands and Environment, Kampala.

Forest Department. (2002, September). National Biomass Study: Technical Report. Ministry of Water, Lands and Environment, Kampala.

Forest Department. (1992, September) National Biomass Study Technical Report, Ministry of Water, Lands and Environment, Kampala. p 61.

Forest Department. (1996). Uganda Scenario 1995-2015 National Biomass Study. Kampala.

Forest Department (2002, September) National Biomass Study Technical Report, Ministry of Water Lands and Environment, Kampala.

Forest Department.(2002, March). National Biomass Study: Draft Technical Report, Ministry of Water, Lands and Environment, Kampala.

Giest H,.(1997) How Tobacco Contributes to Tropical Deforestation: Wood use Statistics of African Tobacco 1986-1997. Utrech.

Government of Uganda . (2001,June). Background to the Budget for the Year 2001/2002. Ministry of Planning and Economic Development, Kampala.

Government of Uganda. (1997, October) Strategic Plan for Uganda Power Sector .Ministry of Natural Resources, Kampala.

Government of Uganda. (2002, September).The Energy Policy for Uganda, Ministry of Energy and Mineral Development, Kampala.

Government of Uganda. (1999, July). The Electricity Act. Ministry of Energy and Mineral Development , Kampala.

Government of Uganda.((2004, June). Background to the Budget for Financial Year 2004/05, Ministry of Finance Planning, Planning and Economic Development, Kampala.

Government of Uganda.(1998, December). Vision 2025: A strategic Framework for National Development. Ministry of Finance, Planning and Economic Development, Kampala, Uganda.

Government of Uganda. (2001, June). Background to the Budget for the Year 2001/2002 , Ministry of Planning and Economic Development. Kampala, Uganda..

Government of Uganda.((2003, June). Background to the Budget for Financial Year 2003/04, Ministry of Finance Planning and Economic Development, Kampala.

Government of Uganda.((2004, June). Background to the Budget for Financial Year 2003/04, Ministry of Finance Planning and Economic Development, Kampala.

Government of Uganda.((2003, June). Background to the Budget for Financial Year 2003/04, Ministry of Finance Planning and Economic Development, Kampala.

Government of Uganda.((2003, June). Background to the Budget for Financial Year 2003/04, Ministry of Finance Planning and Economic Development, Kampala.

Government of Uganda.(2003, June). Background to the Budget for Financial Year 2003/04, Ministry of Finance Planning and Economic Development, Kamapala.

Government of Uganda. (1997). Human Development Report. Ministry of Finance and Economic Development, Kampala.

Government of Uganda.(1997, June). Background to the Budget for Financial Year 1996/97, Ministry of Finance Planning and Economic Development. Kampala.

Government of Uganda (1991). Farming Systems Programme : Ministry of Agriculture, Animal Industry and Fisheries, Kampala.

Government of Uganda (1988). Uganda National Energy Development Organisation Report. Ministry of Natural Resources, Kampala.

Government of Uganda .(2002, September).The Energy Policy for Uganda. Ministry of Energy and Mineral Development, Kampala.

Government of Uganda.(2000, June) The National Energy Balance 1999, Ministry of Energy and Mineral Development, Kampala.

Government of Uganda. (2001, June). Background to the Budget 2001/02, Appendix A6. Ministry of Finance and Economic Development. Kampala.

Government of Uganda.(2001, June). Background to the Budget 2001/02, Appendix A38. Ministry of Finance and Economic Development

Government of Uganda. (2001, June). Background to the Budget for the Year 2001/2002, Ministry of Planning and Economic Development, Kampala.

Government of Uganda. (2000, June). National Energy Balance. Ministry of Energy and Mineral Development.

Government of Uganda. (1999). Electricity Act.1999. Ministry of Energy and Mineral Development. Kampala.

Government of Uganda. (2002, September). The Energy Policy for Uganda. Ministry of Energy and Mineral Development.

Government of Uganda (2002, June).Background to the budget for the year 2002/03. Ministry of Finance, Planning and Economic Development, Kampala ,

Government of Uganda.(2002, October).Uganda Initial National Communication to the United Nations Framework Convection on Climate Change, Ministry of Lands Water and Environment. Kampala.

Godfrey .R. Turyahikayo. (1994) Status of Renewable Energy Technologies Dissemination in Uganda. AFREPREN Working Paper 30 . Nairobi.

Graham,J.A.N.(1997,April). MSc. Thesis, Testing Efficiency of Domestic Stoves, Energy Research Institute, University of Cape Town.
Global Links.(2001). Selected World Development Indicators, Washington, DC.

Hambleton, Anne. (1998).An Annotated Glossary of Commonly Used Climate Change Terms .The Center for Sustainable Development in the Americas. Washington DC.

Hilma R.Zeissing.(2000, June). Analysis and Proposed Reform of the Regulatory Framework for Down Stream Petroleum Market in Uganda
Kampala.

Hans C, Jung H,.(2001, October). Solar Pumping in Uganda, Drinking water for community: Renewable ENERGY World September/ October 2001. London.

Heineken Breweries.(2000). Environment Report 2000. The Netherlands.

http:// www.povertystoves.energy projects.net

http://www.nationmaster.com/country/Energy

Intermediate Technology Development Group (2004, March 19). Smoke and health in Sudan. Smoke: the Killer in the Kitchen Indoor, Air Pollution in Developing Countries. Rugby, UK.

Intermediate Technology Group (2005, February). Boiling Point, Scaling up and commercialisation of household Energy Initiatives, number 50.2005.

IPCC. (1996). Revised Guidelines for National Greenhouse Gas Inventory: Workbook Volume 2.

Jacovelli & Calvalho.(20001, April).Voices from the field, Review of Forestry Initiative in Uganda, Synthesis report Vol. 1.Kampala.

Jivan .E (2005) Scaling up and Commercialisation of Household Energy Initiatives, ITDG, Boiling Point Number 50. Rugby, UK.

Joyce & Burgi.(1993). Cleaner Production Assessment in Dairy Industry. Australian Diary Processors.

Jonhanson, T.B, & Goldemberg, J. (2002). Energy for Sustainable Development: UNDP New York.

Kgathi,D.L, Hall,D.O., Hategeka, A.,Sekhawela, M.B.M.,(eds). (1997). Biomass Energy Policy in Africa. African Energy Policy Research Network, ZED Books, London and New Jersey.

Kennedy and Donkins.(1997). Hydro Power Master Plan. Uganda Electricity Board, Kampala.

Khalema-Rebeby. et al.(1998). Planning and Management in the African Power Sector. African Energy Policy Research Network, Zed Books, London.

Klarer, Swisher, and Kolehmainen. (1999).Synthesis Study of the National AIJ/JI/CDM Strategy Studies Program. World Bank, Swiss AIJ Pilot Program, and Ministry of Environment of Finland. Hesinki.

Les Editions du Fleuve. (1987), Sustainable Development, Paris.

Leach, G and Mearns R.(1988). Beyond the Fuelwood Crisis. Earthscan Publication Limited, London.

Maxime Kleinpeter.(1995). Energy Planning and Policy.. John Wiley and Sons, London.

Ministry of Energy and Mineral Development. (2003, April). Uganda National Energy Balance. Kampala.

Ministry of Energy and Mineral Development.(2003,March 4). http://www.energyandmineral.go.ug/UGA Energy Balance 2003 htm

Ministry of Agriculture. (2000,June). Plan for Modernisation of Agriculture: Eradicating Poverty in Uganda, Ministry of Agriculture, Animal Industry and Fisheries.

Ministry of Energy and Mineral Resources (2000, June).Liberalisation of Petroleum Sub sector in Uganda. Changes and Impact, Kampala.

Ministry of Energy and Mineral Development.(2001, June) Annual Report 2001.

Ministry of Finance Planning and Economic Development.(2003) Uganda Poverty Status Report., Kampala.

Ministry of Finance, Planning and Economic Development (1998).Poverty Trends in Uganda 1992-1996. Discussion Paper No.2, Kampala.

Ministry of Planning and Economic Development.(1999, December). Vision 2025, Background Paper Vol.2. Kampala.

Ministry of Finance Planning and Economic Development. (1999, February). A Strategic Framework for National Development Main Document (Working Draft), For National Dialogue, Vol. I, Kampala.

Ministry of Energy and Mineral Development.(2002). Annual Report 2002
Government of Uganda .(2002, September).The Energy Policy for Uganda. Ministry of Energy and Mineral Development.

Myung-Kyoon Lee. (2004, June). UNEP, CDM information and Guidebook 2nd Ed., Roskilde, Denmark.

Ministry of Education.(2000, June). Education Statistical Abstract 2000, Ministry of Education and Sports. Kampala.

Ministry of Energy and Mineral Development (2003, April). Uganda Energy Balance 2002. Kampala

Ministry of Energy and Mineral Development. (2000). Rural Electrification Strategy and Plan (2001-2010), Kampala, Uganda.

Mubiru, P., (2003,May). Efficient Utilisation of Energy Resources, 8th.Natioanl Conference, Ministry of Energy and Mineral Development, May 2003.

National Environment Management Authority. (1998).State of Environment Report for Uganda. Kampala.

National Energy Balance.(2001, June).Ministry of Energy and Mineral Development. Kampala.

Nigel Bruse. (2001). Kenya Smoke and Health Project 1998-2001.: Intermediate Technology Development Group: Practical Answers to Poverty.

Njeri Wamukonya.(2003). Electricity Reform, Social and Environmental Challenges, UNEP. Roskilde, Denmark.

Nordic Consulting Group. (1999, October).Review of the Norwegian Input to the Energy Sector in Uganda. Ministry of Energy and Mineral Development, Kampala.

Okoth-Ogendo, H.W.O & J.B.Ojwang .(1995). A climate for Development Climate Change Policy Options for Africa. Stockholm Environment Institute, Stockholm.

Oscar Kibazohi. (2005, March 3) Report of the African Clean Development Mechanism, (Unpublished Report) Kampala.

Patience, J. T & Muiruri J.K.(1992). Testing the efficiency of stoves, Adapted from the revised VITA-1985- Regional Wood Energy Programme for Africa. Nairobi.

Partnership for Clean Indoor Air. (2004, November 18) http://www.epa.gov/iaq/pcia.html
Department of Energy.(2004). How to build improved household stoves. Ministry of Energy and Mineral Development. Kampala.

Petroleum exploration and Production Department. (1997).The Hydrocarbon Potential of the Albertine Graben.. Ministry of Energy and Mineral development, Kampala.

Peter Colley.(1997) Reforming Energy. Pluto Press. London

Petroleum Department.(2001, June).Petroleum Products Consumption. Ministry of Energy and Mineral Development, Kampala.

Poverty Reduction aspects of successful Improved Household Stoves Programme.

Rodolfo, Pallabazza & Adam, M.Sebbit.(1998). Data Bank: The Wind resources for Uganda, Pergamon Press , Renewable Energy Vol. 13. Elsevier Science.

Rosillo - Calle et al.(1986). Biomass Energy use in Developing Countries. Commission of European Community.[Europe].

Seale R.L. and Sierka R.A.(1973). Energy Needs and the Environment. 1998-1001 pp, University of Arizona Press

Solarex Corporation.(1992), World Design Insolation. New York.
The Weekly Message News Paper

Schirnding et al .(2002). Addressing the Impact Household Energy and Indoor Air Pollution on Health of the Poor, World Health Organisation. Geneva

The New Vision News Paper.

Tata Energy Research Institute. (1999). Resource Utilisation Improvement in Bricks Industry, Case study, New Delhi.

Thomas B, Jose, G.(2002). Energy for Sustainable Development, A policy Action Agenda, UNDP, New York .

Turyareba P.J., M.J.Kumani.(1992). Testing Efficiency of Cooking Stoves: A Manual for Africa. KENGO/The Regional Energy Programme for Africa (RWEPA), Nairobi.

Turyareba Patience, Drichi Paul.(2001, November). Plan for development of Uganda Biomass Energy Development.

Technology Consult. (1992). Strengthening of Endogenous Capacity in Science and Technology Through National policy Dialogues. Project: INT/OT2-UNDP/OpS. Theme 3: Energy sector identification of alternative forms of energy including new and renewable that can be used to limit the impact on environment. Ministry of Natural Resources, Kampala.

Uganda Bureau of Statistics.(2001,June).Uganda National Household Survey 1999/2000,

Uganda Bureau of Statistics.(2002, November). Population and Housing Census, Preliminary Report, Entebbe.

United States civil liberties NGO Freedom House. (2001). World Report 2000-2001..

Uganda Electricity Board. (2000,June). Monitoring Statistics: 1990-1999.

Uganda Bureau of Statistics. (2002, June). Statistical Abstract 2000. Entebbe, Uganda.

Uganda Bureau of Statistics. ((2002, November). Household Survey 1999/2000. Entebbe.

Uganda Bureau of Statistics. (2002, November). Statistical Abstract. Entebbe.

Uganda Bureau of Statistics. (2002, June).Statistical Abstract 2002. Entebbe.

Uganda Bureau of Statistics. (1999, July). Statistical Abstract, 1999. Entebbe, Uganda.

Uganda Bureau of Statistics .(2001, June). Statistical Abstract 2001. Entebbe, Uganda.
Uganda Electricity Board. (1999, June). Key Monitoring Statistics 1990-1998.

Uganda Investment Authority. (2001,June). Energy Investing in Uganda. Industry Profile, Kampala.

Uganda Electricity Distribution Company. (2000, June). Monitoring Statistics, 2000.

Uganda Railway Corporation.(1999,October).Uganda Railway Corporation at a Glance Today. URC, Kampala.

Uganda Railway Corporation.(2001, June). Bureau of Statistics, and Statistics Section,

Uganda Railways cooperation, to be privatised. (2002, June 17-23) .The East African newspaper .

UNDP&World Bank.(1983, July).Uganda: Issues and Options in the Energy Sector. Energy Sector Assessment Program, Washington, D.C.

UNDP/World Bank. (1996, March). Uganda Energy Assessment. Energy Sector Assistance Programme , Washington DC.

UNDP &World Bank.(1999, January).Uganda Rural Electrification Study, Energy Sector Management Assistance Programme.

UNDP &World Bank. (1999, January).Uganda Rural Electrification Strategy Study. Energy Sector Assessment Program, Washington.

UNDP/World Bank.(1996, March). Uganda Energy assessment. Energy Sector Management Assistance Programme, Uganda Energy Assessment, annex 2.

UNDP/World Bank..(1996, March). Uganda Energy Assessment: Energy Sector Assistance Programme. Washington, DC.

UNDP/ World Bank. (1996, March). Joint UNDP/World Bank Energy Sector Management Assistance Programme, Washington DC.

UNDP & World Bank. (1999, January). Rural Electrification Strategy Study. Energy Sector Management Assistance Programme, Washington, DC.

UNDP & World Bank.(1983) Uganda: Issues and Options in Energy Sector. ESMAP. Washington, DC.

United Nations Framework Convention on Climate Change and the Kyoto Protocol to the UNFCCC. www.unfccc.de

UNIDO & Sustainable Industrial Development.(2001,August).Energy Conservation in Cement Industry: Production process in cement industry.

United Nations Environment Programme. (2002).Africa Environment Outlook. Policy and Action Recommendations for a Sustainable Development Nairobi.

United Nation Development Program /Department of Economic and Social Affair. /World Energy Council/ World Energy Assessment. (2005, January) http://www.itdg.org/?id=iap_who.

UNDP /World Bank. (1986). Bank Energy Sector Management Assistance Programme. Washington, DC.

United Nations Framework Convention on Climate Change and the Kyoto Protocol to the UNFCCC. www.unfccc.de

UNDP/World Bank.(1996, March). Uganda Energy Assessment. Energy Sector Assistance Programme , Washington, DC.

UNDP. (1997). Industrial Development Review Series: Uganda, Sustainable Stabilisation and Industrial Growth, New York.

UNDP & World Bank.(1996, March). Uganda Energy Assessment. Energy Sector Management Assistance Programme. Washington. D.C.

UNDP. (2004). Human Development Report 2004,. New York.

Uganda Electricity Board.(2000).Monitoring Statistics: 1990-1999.

Uganda Bureau of Statistics. (2000, June). Household Survey 1999/2000. Entebbe, Uganda.

Uganda Bureau of Statistics.(2000, July) Statistical Abstract.

Uganda Electricity Distribution Company Ltd. (2001). Key Monitoring Statistics1992-2000

Uganda Railway Corporation. (2002, December). Transaction Advisory Services, Due Diligence Report Vol.1. Kampala.

Uganda Energy Assessment.(1996, March). Uganda Energy Assessment: Energy Sector Assistance Programme. Washington, DC.

Uganda Electricity Board. (2001). Monthly monitoring parameters, January–December 2000 , Kampala.

UNDP & World Bank. (1999), January).Uganda Rural Electrification Strategy Study. Energy Sector Assessment Program.

UNDP & World Bank .(1996, March) Uganda: Energy Assessment. Energy Sector Assistance Programme.

Virate Tig Tuntivate.(1997, September). Uganda Non Grid Rural Electrification. Analysis of Household Energy Survey. Ministry of Energy and Mineral Development. Kampala

Winrock International consultant . (2005, February).Partnership for Clean Indoor Air.

World Bank .(2000, January). Uganda: Energy for Rural Transformation

World Bank. (2003).World Development Indicators.. Washington, D.C.

World Bank.(2005). World Development Indicators, Washington, D.C.

World Bank.(2005). Global Development Finance, Washington, D.C.

World Bank. (2001). World Development Indicators, Washington ,DC,

Uganda Government.(2002, October).Uganda National Communication to the United Nations Framework Convection on Climate Change. Ministry of Water, Lands and Environment. Kampala.

World Commission on Environment and Development. (1987). Our Common Future, Oxford University Press, Oxford.

World Bank.(2000). Prototype Carbon Fund, Washington, D.C.

World Bank. (2001).Selected World Development Indicators ,Washington D.C.

World Bank (1993) World Bank Policy Paper.: Energy Efficiency and Conservation in Developing World. Washington, DC.

World Bank IENPD, Energy for Sustainable Development Ltd. (1995, June).A Review of renewable Energy Resources and Technologies in Uganda Final Report, Kampala.

World Bank. (2005).World Development Indicators, Washington DC.

World Bank . (2003). World Development Indicators, Washington, DC.

World Bank. (1998). World Development Report 2000/2001, Washington, DC.

World Bank. (2001). World Development Indicators, Washington, DC.

World Health Organisation. (2000). Addressing the Link between Indoor Air Pollution Household Energy and Human Health Geneva.

World Energy Council. (1988). Rural Energy in Developing Countries. Vol. 1, UK.

World Energy Council.(1998). Rural Energy in Developing Countries. Vol. 3, UK.

World Energy Council.(1998). Rural Energy in Developing Countries. Vol. UK,

World Bank. (2000, January) Uganda: Energy for Rural Transformation, AFRRIE Mission : Draft Aide Memoire.

World Bank.(2001, February).Energy for Rural Transformation Project , Project Appraisal Document. Washington, DC.

World Bank. (2001). Development Report 2000/2001, Washington D.C.

World Bank .(2002). Prototype Carbon Fund Annual Report. Washington, DC

World Bank.(2003).World Development Indicators, Washington D.C.

World Health Organization. (1997). Health and environment in sustainable development: five years after the Earth Summit. Geneva.

World Bank & Private Sector Foundation. (1996). Generator Usage in industrial and Commercial sectors. Private Sector Foundation. Kampala.

APPENDIX A

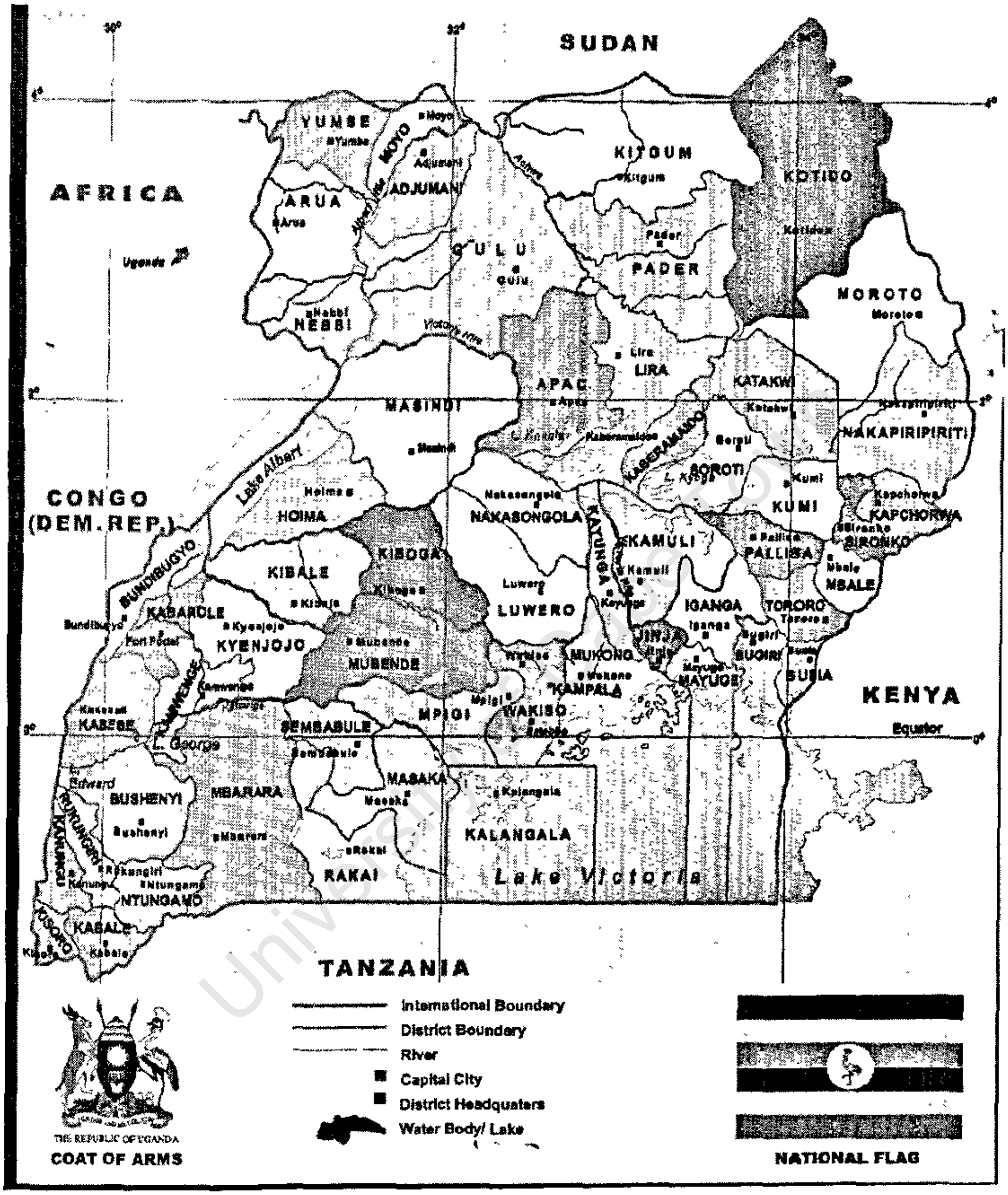


Figure A1.1: Map of Uganda with districts

The map of Uganda shows the number of districts in 2005. During the survey there were forty five but at present there are sixty five districts.

PRESENT AND FUTURE UEB NETWORK

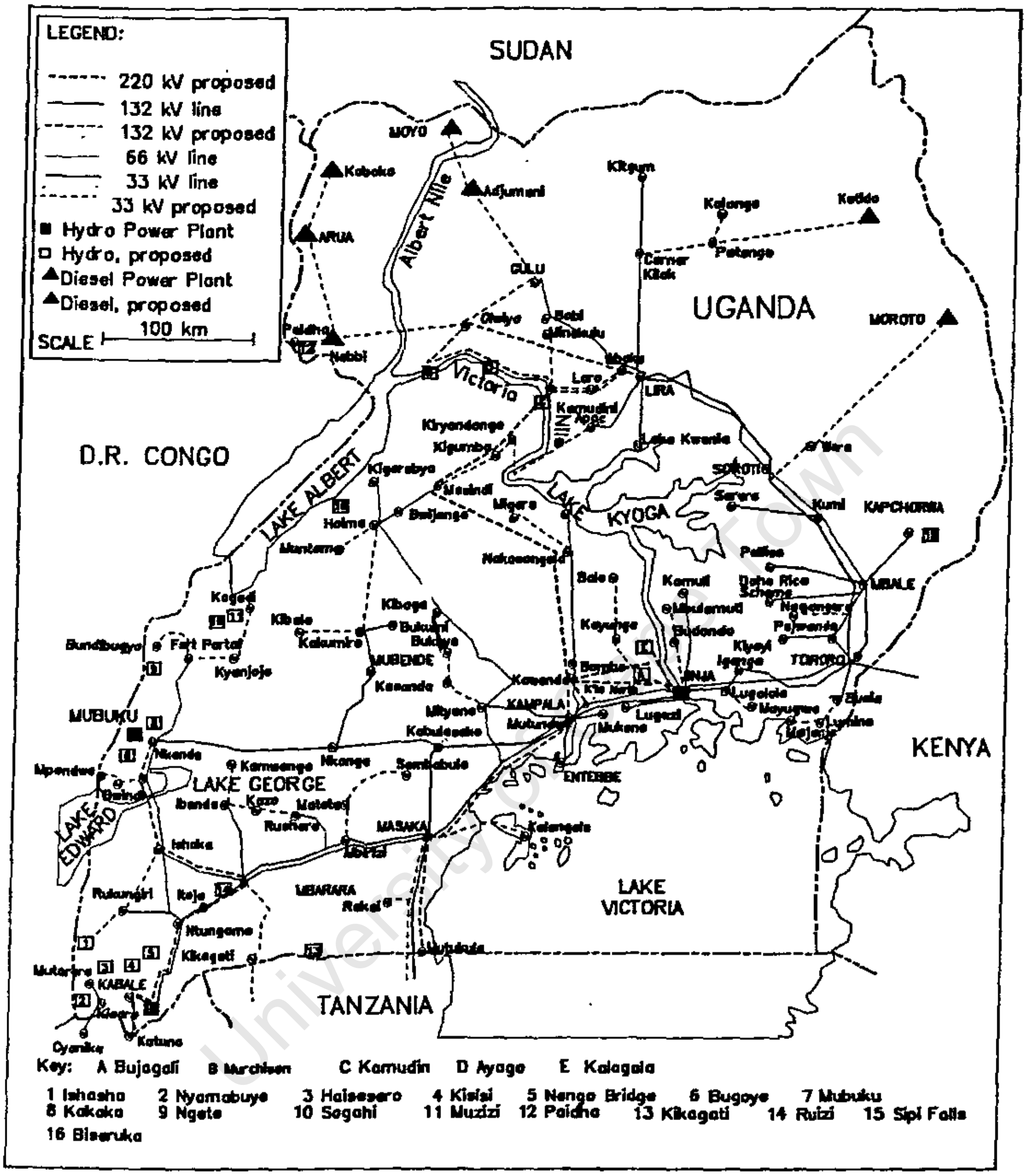


Figure A2.1 : The present and future network for power transmission
The figure shows that eventually the towns will be connected to the main grid. The major transmission lines from power stations to major load centre will be 220 KV.

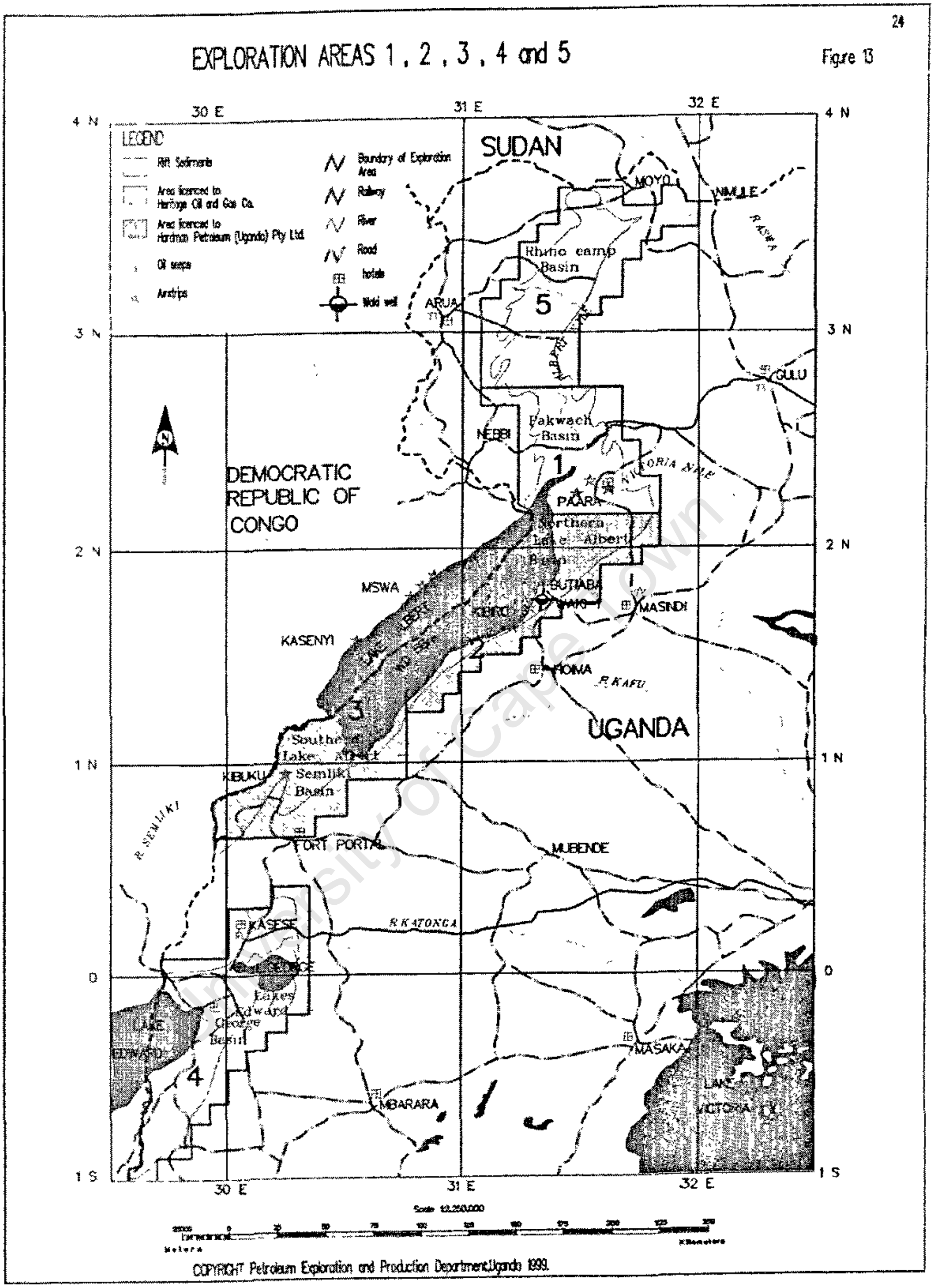


Figure: A2.2 : Hydrocarbon potential for Uganda .

All the potentials for hydrocarbons lie in western parts of Uganda. The explorations areas are licensed to different companies.

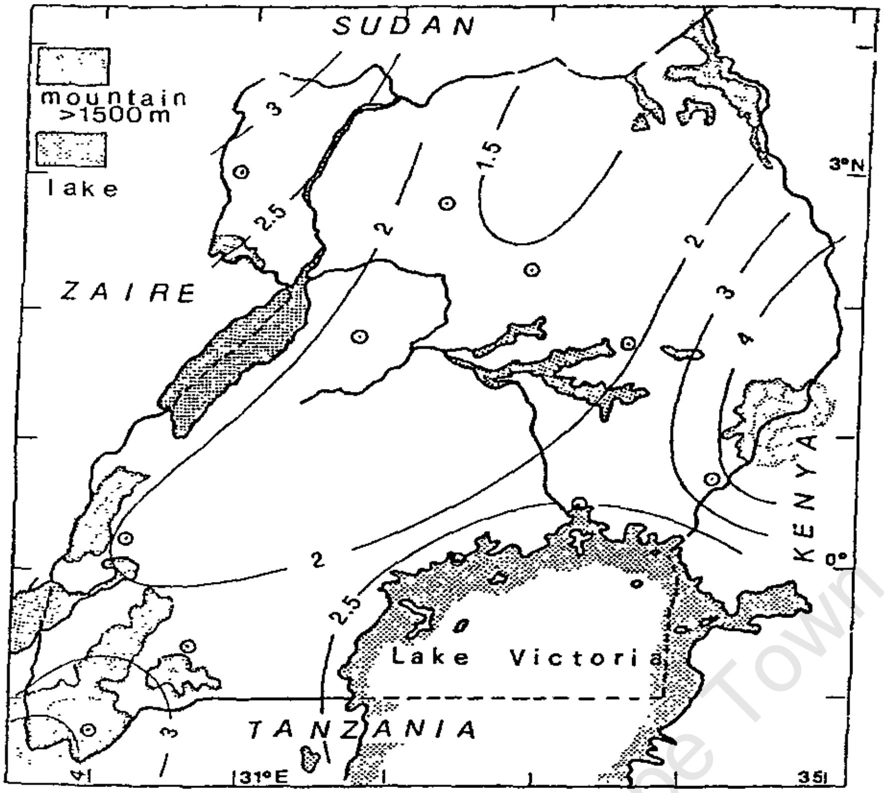


Figure A2.3 : Wind speed distribution in Uganda

The wind speed generally is less than 3 meters per second. Apart from the areas bordering mountains where the wind speed is 4 meters per second.

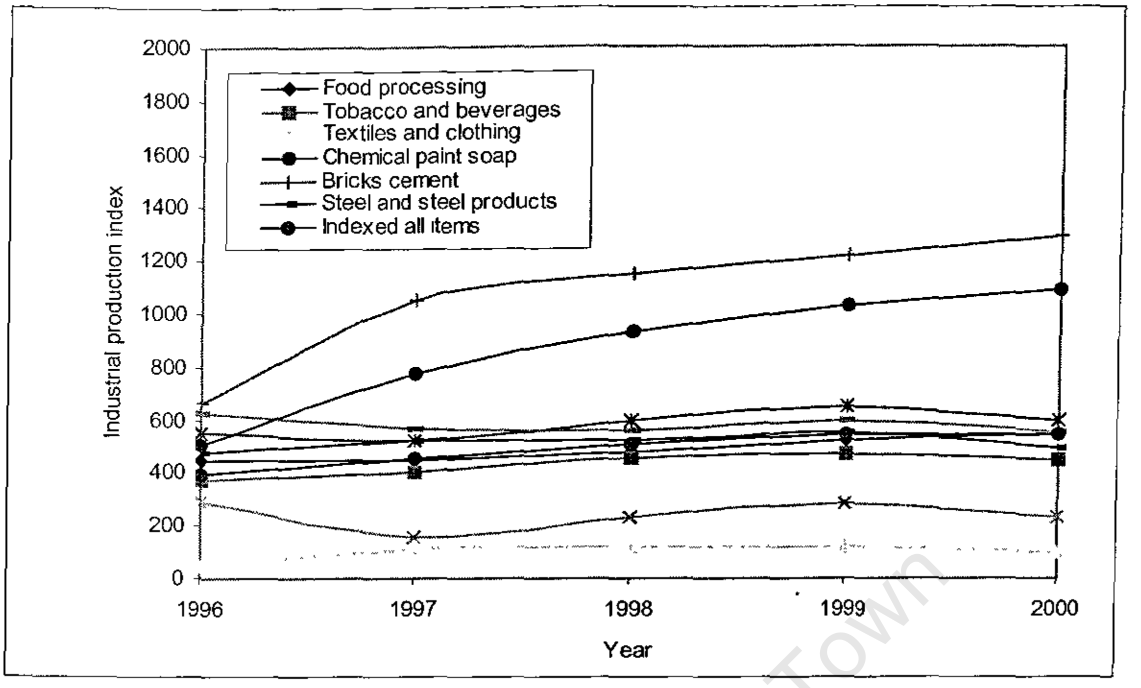


Figure A6.1 : Industrial production index (1996-2000).

There is a general increase in industrial production index. There was high rate of increases from 1986 to 1998 it stabilised. The highest increase was in bricks and cements that was due to high rate of construction.

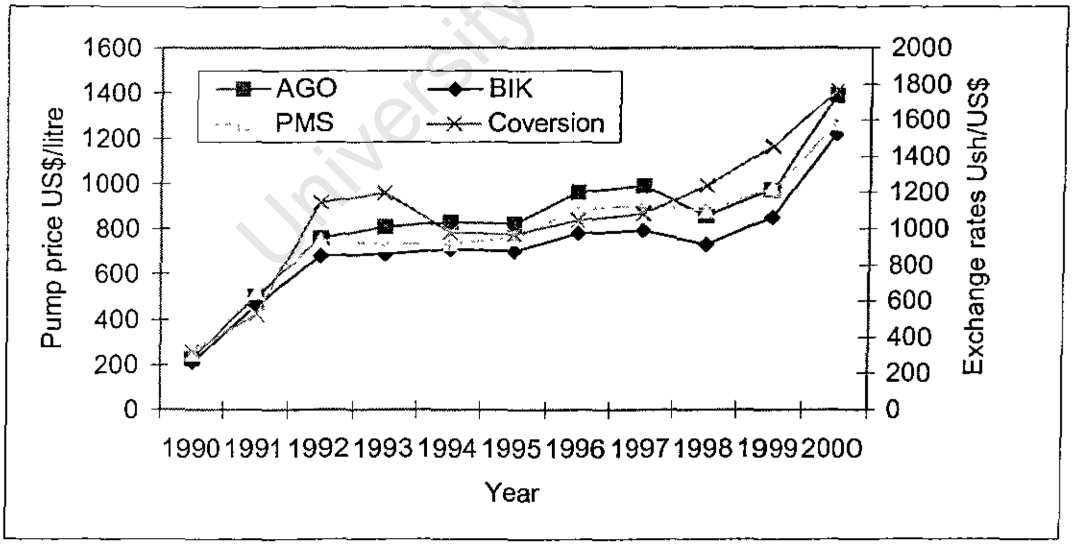


Figure A6.2:The relationship between the pump price and exchange rates

AGO stands for diesel, BIK stands for kerosene and PMS represents petrol. The price fuel was tagged to the foreign exchanges rates. That means the pump prices vary as the exchange rate fluctuates

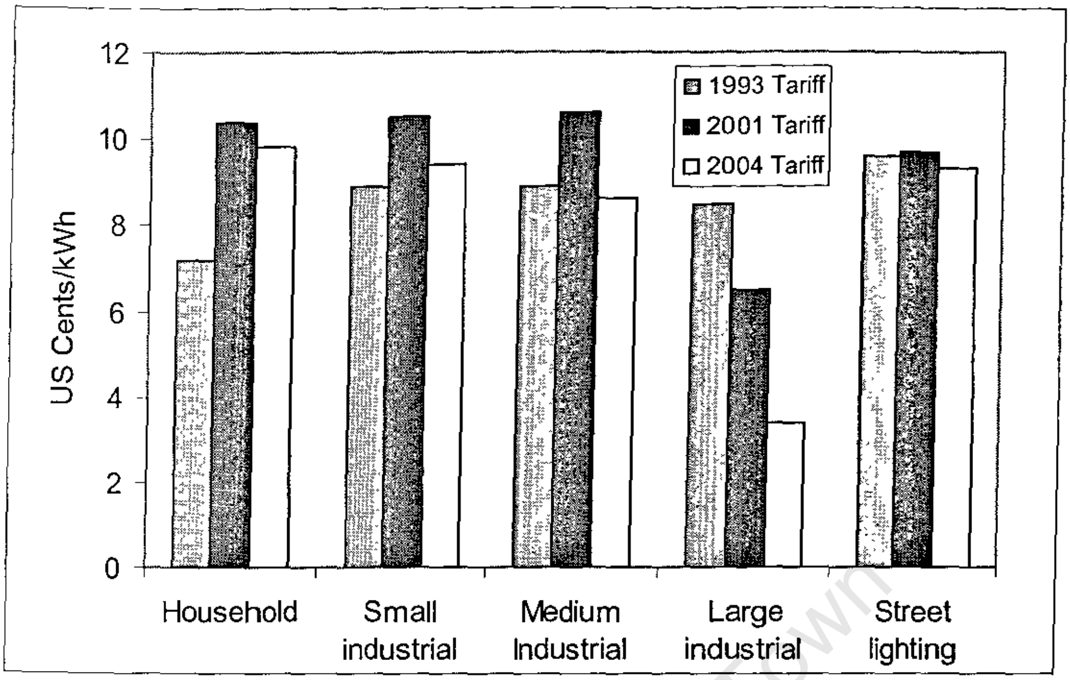


Figure A6.3: Changes electricity retail tariff from 1993 to 2004

There have been continuous changes in tariff. The tariff was highest in 2001. There seems to be reduction in tariff but was not the case that was because of the fluctuations of the foreign exchange rates.

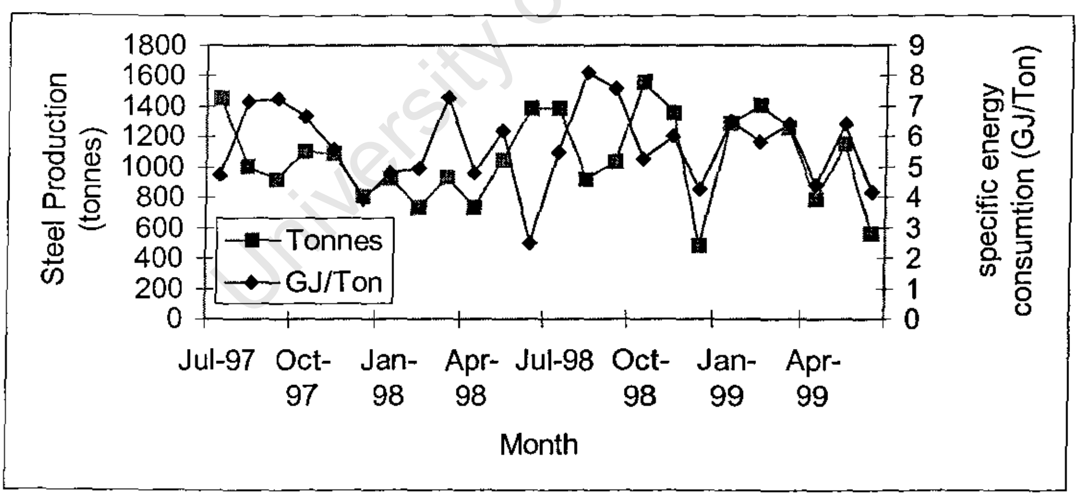


Figure A6.4 Tororo Cement Factory, cement production and specific energy

It can be seen, at high production rates, specific energy decreases. The specific energy increases at low rate of production.

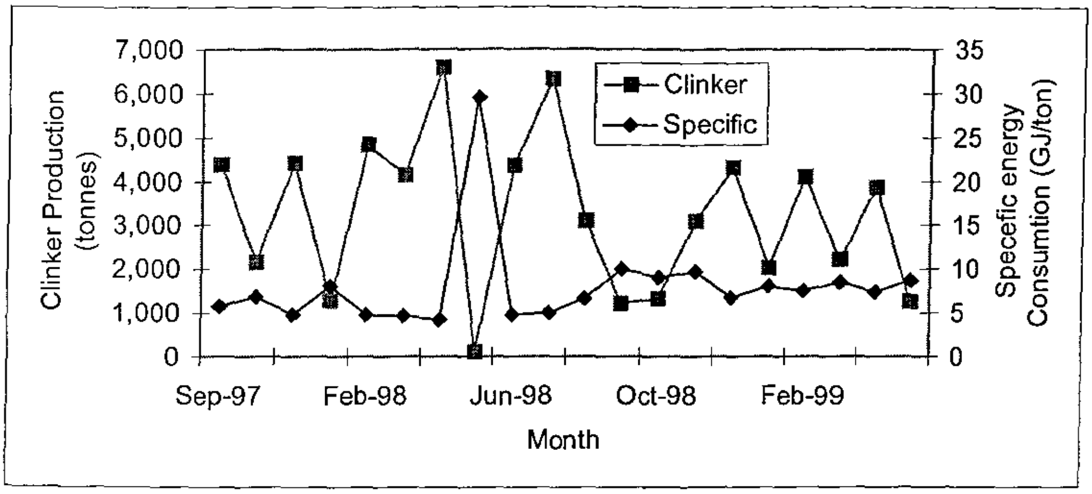


Figure A6.5 : Hima Cement Factory, cement production and specific energy.

At high clinker production rates the specific energy consumption is low. Despite variations in clinker production, the variation in specific energy consumption generally it is not significant. Except in cases where is lowest rate of operation, that is when a significant rise in specific energy consumption.

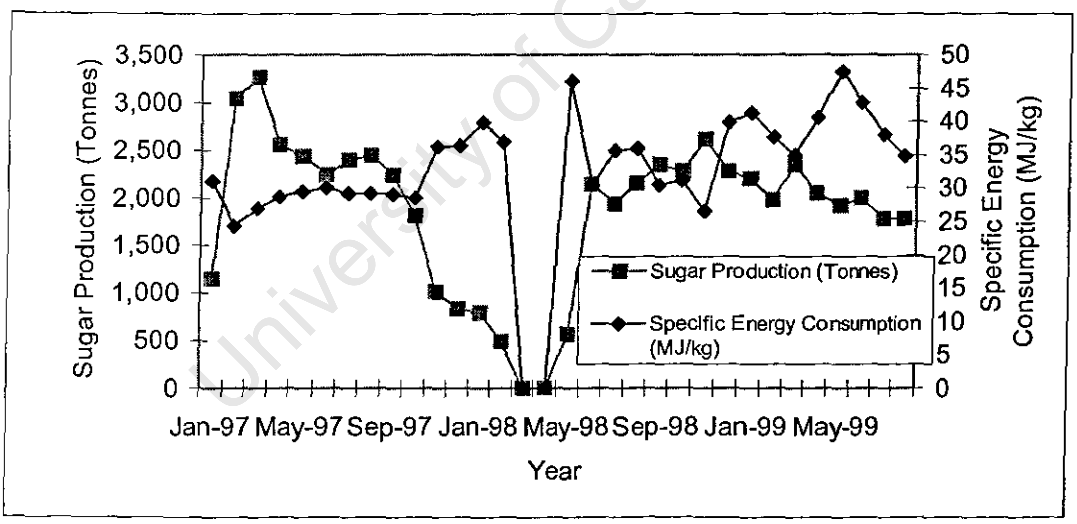


Figure A6.6 :Sugar production and specific energy consumption for SCOUL

The general trend is that specific energy decreases with increasing production. If the production is below 2000 tonnes, the specific energy stars to increases significantly. In the month of May there was major maintenance.

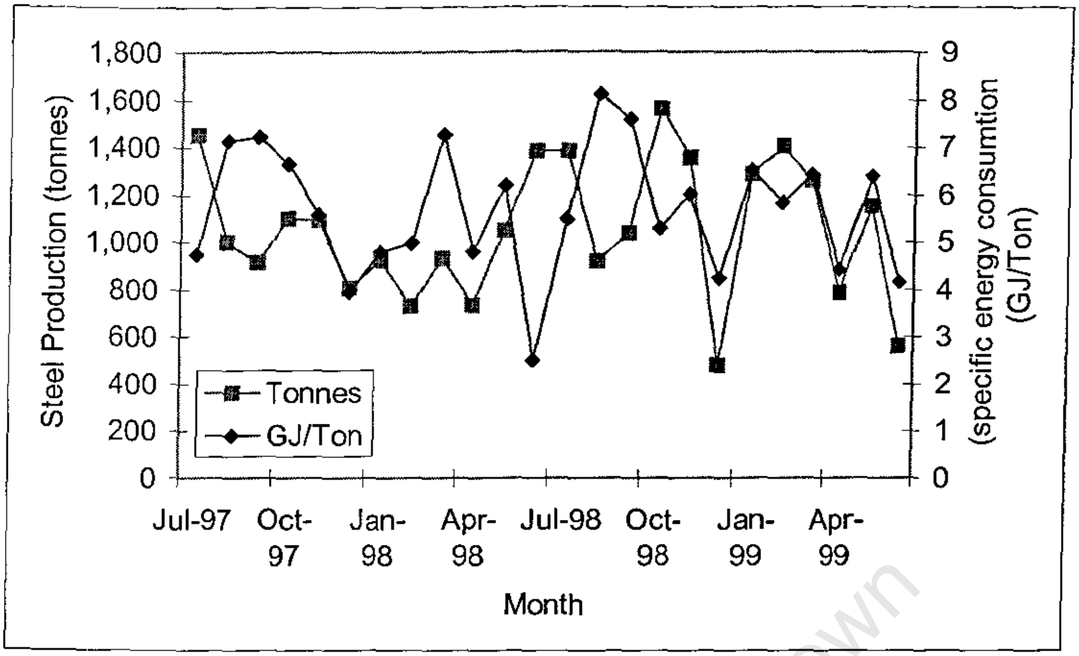


Figure A6.7 : Steel Rolling Mills, steel production and specific energy consumption

When the production is between 1,400 and 1200 per month, the specific energy consumption is lowest. Once the production rates less than 1,000 tonnes per month, there is appraisable increases in specific energy consumption.

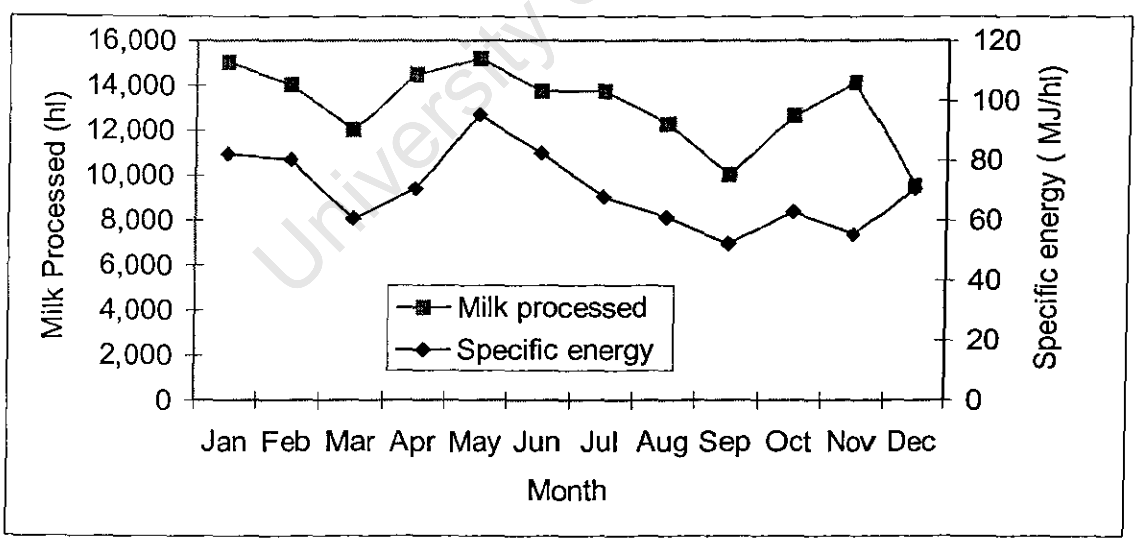


Figure A6.8 : Milk production and specific energy consumption for Diary Corporation

The trend in this sector specific energy increases with increasing production.

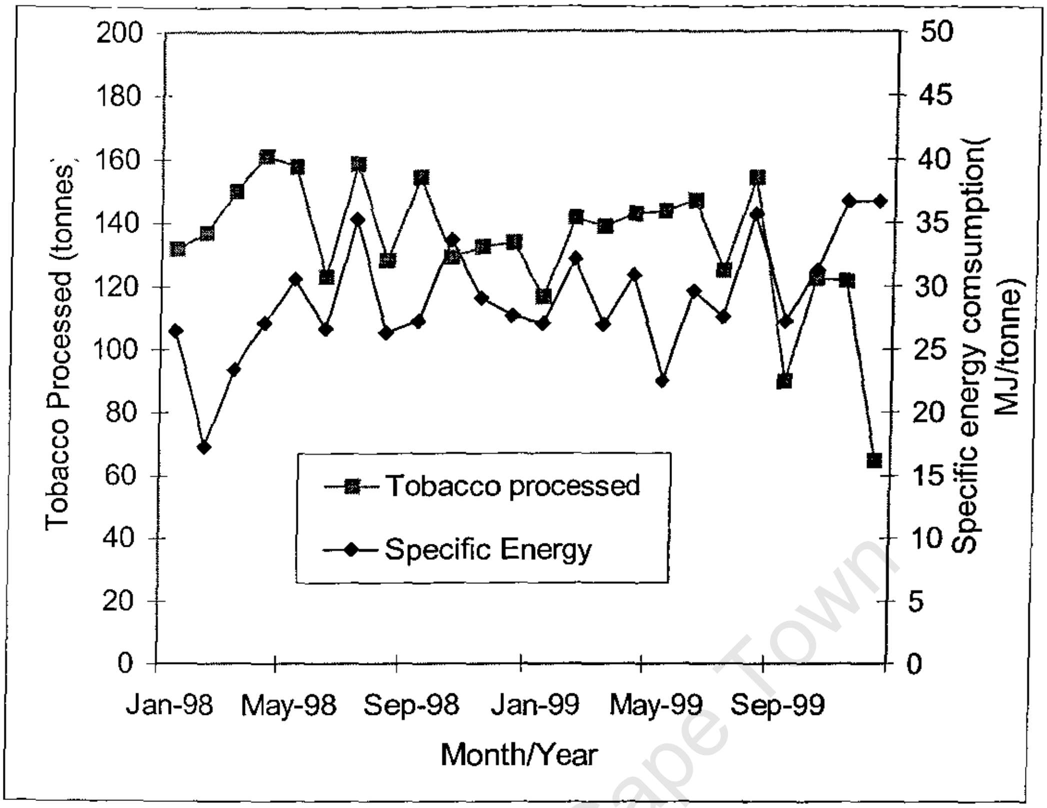


Figure A6.9 : Specific energy consumption and tobacco processed in BAT

The specific energy increases with decreasing amount of tobacco processed, especially when the amount of tobacco processed is less than 120 tonnes per month.

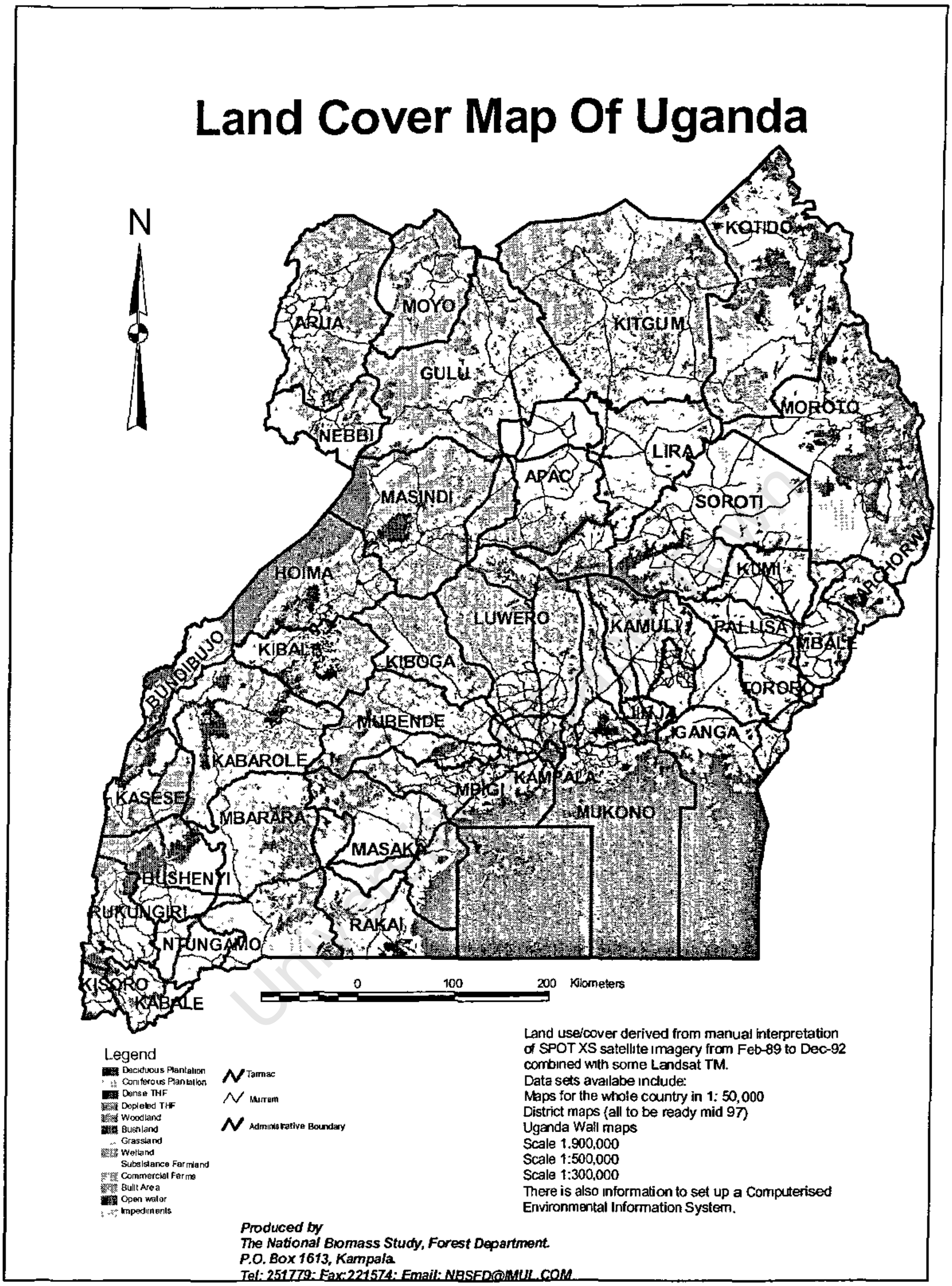


Figure A8.1 : Uganda Land Cover Map

The high tropical forest is disappearing. There a large areas of degraded forests.

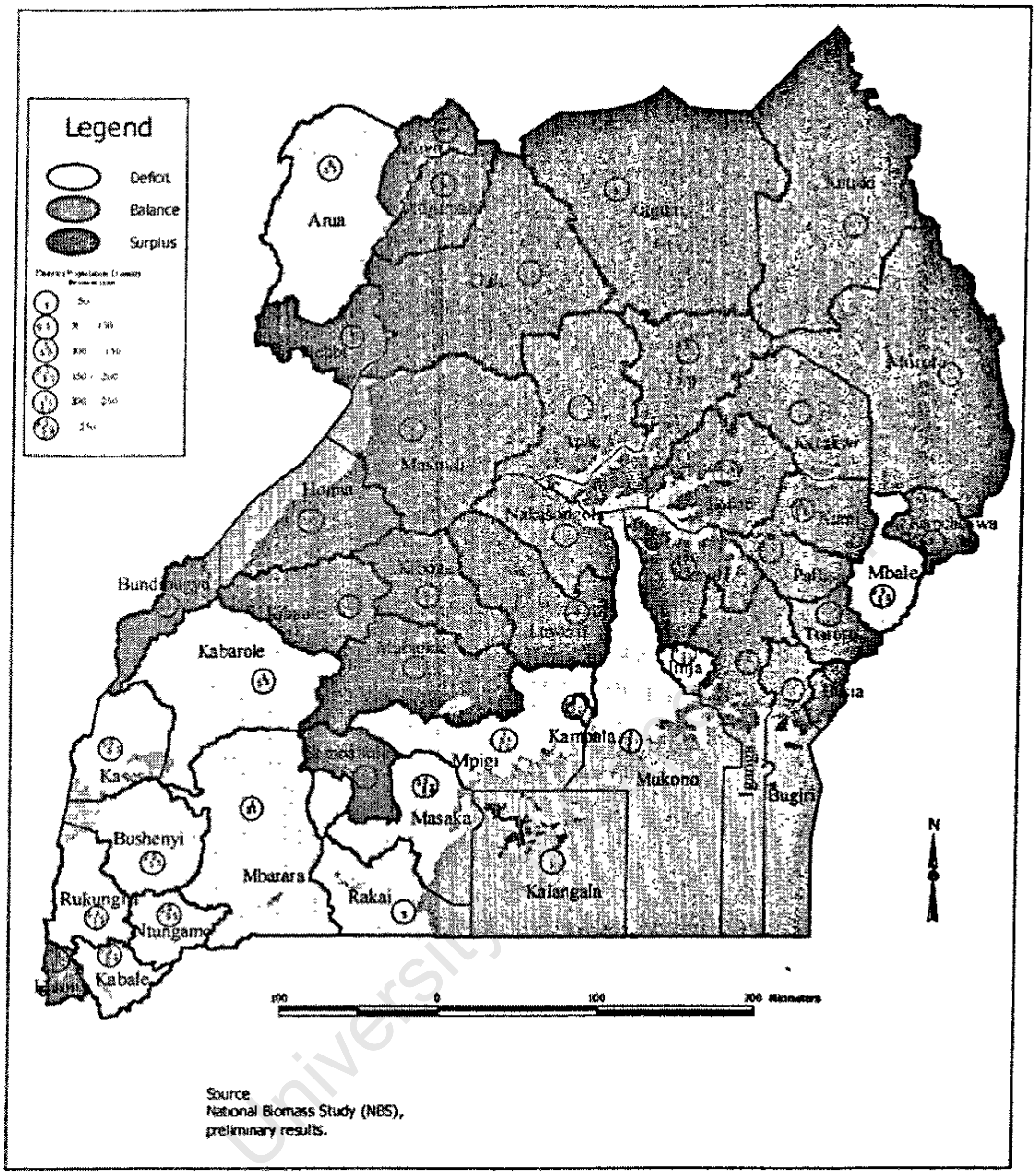


Figure A8.2 : Wood availability in different regions.

It can clearly be seen that in about 30% of the country the biomass supply is in surplus mostly in northern region. There are deficit in about 30% of the country. It covers mostly western part and central region. The rest of the country biomass supply is at balance.

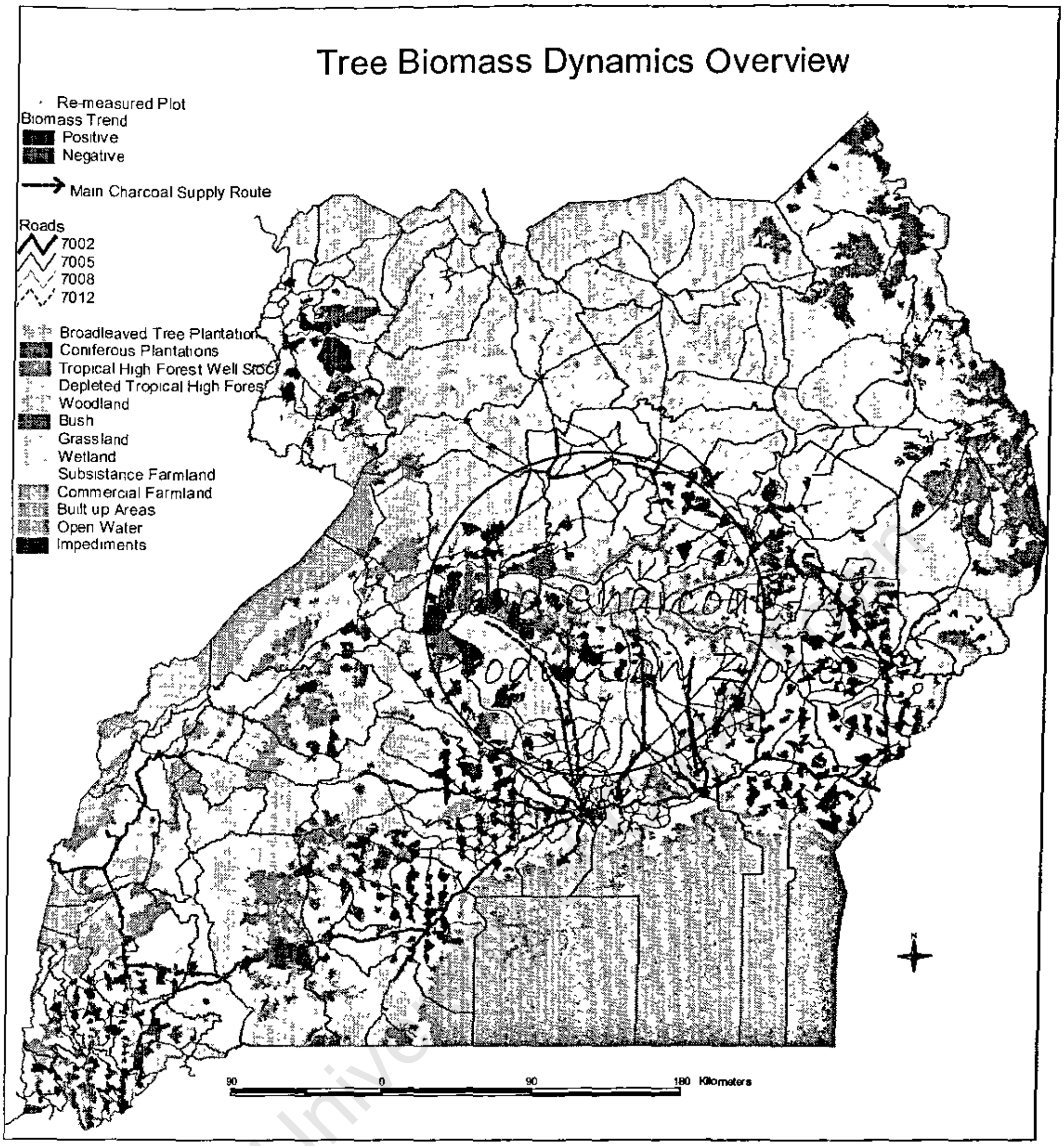


Figure A 8.3: The main charcoal production zone

Charcoal is produced mostly from firm subsistence farm land and wood land. The biomass trend in the area is negative i.e. there is depletion of biomass.

APPENDIX B

Table B2.1: Potential sites for large-scale hydro power plants on River Nile

Hydropower sites	Estimated capacity (MW)
Bujagali	320
Kalagala	450
Kamdini	180
Ayago North	304
Ayago South	234
Murchison Falls	642

Source: Ministry of Natural Resources 1992
The major hydroelectric sites are along the River Nile. The hydroelectric potential is about 2000 MW.

Table B2.2: Potential sites for mini and small hydro power plants

Site	River	District	Estimated Capacity (MW)
Muzizi	Muzizi	Kibale	10
Buyoge	Kasese	Kasese	7.5
Nengo Bridge	Ntungu	Rukungiri	12
Biseruka	Wambabya	Hoima	10
L. Bunyonyi	Bunyonyi	Kabale	1
Nsongezi	Kagera	Mbarara	2
Paida A	Nyagak	Nebbi	3
Paida B	Nyagak	Nebbi	2
Ishasha A	Ishasha	Rukungiri	3.7
Ishasha B	Ishasha	Rukungiri	3.6
Nyamabuye A	Kaka	Kisoro	3.1
Nyamabuye B	Kaka	Kisoro	0.7
Kakaka	Ruimi	Kabalole	1.5
Kikagati	Kagera	Mabarara	1.3
Ruizi	Ruizi	Mbarara	0.7
Sogahi A	Sogahi	Kabalole	2.7
Sogahi B	Sogahi	Kabalole	3.0
Siti	Siti	Kapchorwa	1.0
Sipi	Sipi	Kapchorwa	2
Ngeta	Tokwe/Hanya	Bundibugyo	-
Kitumba Dam	Sogahi	Kabalole	-

Source: Ministry of Natural Resources 1992
There are a number of small scale hydropower plants in the located country wide. The total capacity is about 70 MW.

Table B2.3: Wind speed for different sites in Uganda

No	Name of location	Mean wind speed m/s
1	Arua	2.9
2	Gulu	1.9
3	Soroti	2.1
4	Masindi	2.0
5	Lira	2.0
6	Kasese	1.9
7	Mbarara	2.4
8	Kabale	3.7
9	Jinja	2.6
10	Tororo	3.9
11	Entebbe	2.3

The wind speed at most the sites are low. At these low speeds, the wind energy can find application in water pumping.

Table B2.4: Estimates for the construction of electric power lines

Construction of lines	Description	Estimated cost
Low Voltage		
3 Phase 440 V	Materials estimates	US$ 21,000 per km
Single Phase 220 V	Material estimate	US$ 16,300 per km
High Voltage		
33 kV	Material estimate	US$ 37,400 per km
Transformers		
25 kVA	33kV/250 V and accessories	US$ 9,200
50 kVA	33kV/433 V and accessories	US$ 10,500
100 kVA	11kV/433 V and accessories	US$ 11,100
100 kVA	33kV/433 V and accessories	US$ 11,100

The estimated cost of construction of low voltage transmission lines the cost of transformers and its accessories. The electric system distributing companies will have to make large investment if most of the country is to be connected to grid.

Table B6.1: Average household size by residential status

	1991 Census	1992/93 Survey	1997 Survey	1999/2000
Uganda	4.8	4.8	5.0	5.2
Rural Areas	4.9	4.9	5.1	5.4
Urban Areas	4.0	4.1	4.4	4.4
Regions				
Central	4.3	4.4	4.6	4.8
Eastern	4.9	4.9	5.1	5.3
Northern	5.1	5.1	5.0	5.3
Western	5.2	4.9	5.3	5.7

The sizes of the household in the rural areas are larger than urban areas. The western regions have the highest number of household, while central region have the least number of households size.

Table B6.2: Monthly income by category by percentage (%)

	1997		2000	
Uganda	Rural	Urban	Rural	Urban
Monthly income	100	100	100	100
0-50,000	51	21	32	12
50,000-100,000	29	24	33	24
100,000-150,0000	11	16	16	14
150,000-200,000	4	12	8	12
Over 200,000	5	27	11	38

The percentage of low income households has been reducing, the medium and high come households have been increasing. This shows that the income of households was on increase.

Table B6.3: Estimated monthly electric energy consumption per income category (kWh)

Income Category	Low Income	Medium Income	High Income
Rural	9.90	68.85	248.87
Urban	31.95	133.95	721.35

The low income household consumes the least amount of the energy. It is very expensive to supply power to these people.

Table B6.4: Energy consumption in rural households (PJ)

Activity	Energy source	Low-income	Medium- income	High-income
Cooking	Firewood	51.24	86.77	37.36
	Charcoal	0.00	1.05	0.73
	Agric.residue	7.92	7.72	0.58
	Kerosene	0	0.1	0.092
	Electricity	0	0.011	0.042
Lighting	Kerosene	0.177	0.625	0.599
	Electricity	0.002	0.014	0.018

The fire wood and agricultural is the lagers source of energy for all categories of household. The contributions of electricity and kerosene are very small.

Table B6.5: Rural households' energy intensity per activity (GJ)

Rural	Energy Source	Low income	Medium income	High income
Cooking	Firewood	50.70	54.6	58.50
	Charcoal	0	8.629	13.116
	Agriculture Residue	42.12	49.14	56.16
	Kerosene	0	0.945	1.890
	Electricity	0	1.289	8.157
Lighting				
	Kerosene	0.274	0.597	1.327
	Electricity	0.427	1.684	2.591

In the rural households, annual energy intensity is higher for the high income than low income households. They have larger household size and have wider access to alternative fuels. The energy intensity was used in LEAP.

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In the rural households, annual energy intensity is higher for the high income than low income households. They have larger household size and have wider access to alternative fuels. The energy intensity was used in LEAP.

Table B6.6: Energy consumption in urban households (PJ)

Activity	Energy source	Low-income	Medium- income	High-income
Cooking	Firewood	1.819	3.66	4.037
	Charcoal	0.758	4.90	8.14
	Agric.residue	0.142	0.37	0
	Kerosene	0	0.02	0.06
	Electricity	0	0.044	0.498
	LPG	0	0	0.026
Lighting	Kerosene	0.0208	0.161	0.354
	Electricity	0.001	0.087	0.482

Charcoal is the leading source of energy for medium and high income households. Low income households depend on agricultural wastes. Most of the electricity is used by the high income households.

Table B6.7: Urban households' energy intensity per activity (GJ)

Activity	Energy source	Low-income	Medium- income	High-income
Cooking	Firewood	46.80	50.70	54.60
	Charcoal	17.94	22.78	26.23
	Improved stoves	0	15.186	15.17
	Agriculture Residue	42.12	45.63	0
	Kerosene	0	0.945	2.85
	Electricity	0	1.289	8.157
	LPG	0	0	7.38
Lighting				
	Electricity	1.380	2.009	5.054
	Kerosene	0.411	0.926	1.360

The energy use intensity for different categories of households. It is only the low income households that depend on the agricultural wastes. The high income house holds have the high test energy intensity.

Table B6.8: Industrial energy consumption national energy balance (PJ)

Period	1999	2000	2001
Woodfuel	15.32	16.08	16.89
Fuel oil	1.6	1.32	1.43
Diesel	0.63	0.66	0.68
Electricity	0.59	0.74	0.8
Total	18.14	18.82	19.82

Woodfuel is a very important source of energy in industrial sector. The use of other sources of energy is relatively low. Fuel oil is the second most important fuel.

Table B6.9: The leading electricity energy consuming industries in Uganda (2000)

	Industry	Electric energy per annum		Percentage
		kWh	GJ	
1	Hima Cement Factory	33,190,800	0.119	16.10
2	M/S Steel Rolling Mills	26,816,400	0.097	13.01
3	Sugar Corporation Lugazi Ltd.	16,357,692	0.059	7.94
4	National water and Sewage	30,335,196	0.109	14.72
5	Tororo Cement Industries	14,640,000	0.053	7.10
6	M/S Mukwano Industries	11,729,196	0.042	5.69
7	Southern Range Nyaza	9,355,200	0.034	4.54
8	Bakhresa Grand	8,953,200	0.032	4.34
9	Kampala Sheraton Hotel	7,714,800	0.028	3.74
10	Uganda Breweries	7,569,600	0.027	3.67
	Total industrial		0.742	80.86

The table above shows the ten leading industries in terms of electric energy consumption.

Table B6.10: Electricity Retail Tariff for supply of Electricity in Uganda Effective 1st.June 2001 in UGShs.

Category	Consumption	Unit charge kWh
Residential and others limited at low voltage single phase	The first 15 kWh Above 15 kWh	50.00 171.4
Low Voltage supply not exceeding 100A- small general services	All ranges	164.8
Low voltage for medium-scale Industries ,	Maximum demand 500 kVA	150.3 5,000 per kVA
Off peak low voltage for medium Scale industries	Maximum demand 500 kVA	94.5 5,000 per kVA
High voltage to large industrial users	Maximum demand Exceeding 500 kVA Up to 2000 kVA above 2000 kVA	75.3 3,300.00 per kVA 3,000.00 per kVA
Off peak high voltage to large industrial users	Maximum demand Exceeding 500 kVA Up to 2000 kVA above 2000 kVA	32.9 3,300.00 per kVA 3,000.00 per kVA

There is differential tariff for electricity. The first 15 kWh for residential is called line tariff. The tariff increases as the energy consumption increases. Industries pay for energy in terms of the energy consumed and in addition pay per kVA. The industrial tariff is lower than all other sector in order to promote industrial sector.

Table B6.11: Energy consumption in production of clinker (GJ)

Month	Clinker	Fuel oil	Electricity
September 97	4,377	22.05	2.50
October 97	2,163	12.10	2.43
November 97	4,416	17.82	2.91
December 97	1,289	7.80	2.31
January 98	4,840	20.32	2.46
February 98	4,144	16.40	2.41
March 98	6,589	24.75	2.30
April 98	113	0.77	2.54
May 98	4,367	17.72	2.68
June 98	6,333	27.99	2.79
July 98	3,086	15.57	4.51
August 98	1,212	6.23	5.75
September 98	1,337	6.46	5.51
October 98	3,087	24.07	5.16
November 98	4,314	24.08	4.15
December 98	2,026	12.59	3.32
January 99	4,100	24.21	5.79
February 99	2,215	12.59	5.93
March 99	3,870	20.93	7.29
April 99	1,268	7.29	3.50
May 99	65,146	321.74	76.23

Energy consumption for a clinker in Uganda Cement Factory Tororo. The data was used to compute specific energy consumption. The result was compared with other cement factories.

Table B6.12: Typical specific energy consumption in Indian cement industries

Item	Description	Range	Average	Range (GJ/t)
I	Specific electrical energy- of clinker consumption (up to clinkerisation)	59-121 (kWh/t)	81	0.21-0.43
II	Specific electrical energy- consumption (up to cement packing)	86-143 (kWh/t)	114	0.31-0.51
III	Specific thermal energy – of clinker consumption	720-1827 (kcal/kg)	880	3 -7.8

The Indian cement factories, specific thermal energy consumption vary between 3 GJ per and 7.8 tonne. Those cement factories specific thermal energy consumption of 3 GJ/t are as efficient as the Japanese cement factories. In Uganda the average specific thermal energy consumption is 6.11 GJ per tonne. There is potential for reduction.

Table B6.13: Energy consumption, sugar and by products for SCOUL (1997-1999)

Year	MWh	Sugar Tonnes	kWh/kg	Bagasse/ Sugar	Molasses /sugar	Firewood (tonnes)	Furnace oil (l)
1997	18,470	25,420	0.73	3.37	0.53	105	91,000
1998	14234	17,6000	0.81	3.39	0.54	267	68750
1999	10,054	13,956	0.887	5.4	0.56	8	0

Table B6.14: Annual production of bricks and tiles and specific energy consumption

Company	Products Tonnes	Electricity kWh	Diesel (litres)	Furnace oil (litres)	Biomass (husks)m^3	S.Energy MJ/kg
Pan African Clay Works	10,250	650,000	69,600	160,000	4,000	2.666
Uganda Clays Ltd	29,911	666,184	67,528	270,000	6,712	1.482

Different energy sources are used in bricks and tiles factories. Fossil fuels are used in tiles manufacture, while biomass is used in bricks production. The specific energy for

Uganda Clays is lower because they have better equipment and the production rates are much higher than Pan African Clay Works.

Table B6.15: National Water and Sewage Corporations Specific energy consumption

Period of Operation	Water Produced (m^3)	Specific Energy Consumption (kJ/ m^3)	Cost per unit of water produced (UGShs / m^3)
Jan-Dec 1997	35,413,639	2.268	73
Jan-Dec 1998	35,703,243	2.34	75
Jan-Nov 1999	25,353,285	3.132	101

The specific energy consumption for water pumped is high for low volumes of water pumped. There is increased cost per unit of water pumped at low pumping rates.

Table B6.16: Comparison between traditional and improved lime kilns

	Traditional kiln	Improves kiln
Capacity	5-20 tonnes a week	7-10 tonnes a day
Production process	Intermitted	Continuous
Production quality	Low	High
Fuel consumption Firewood: limestone	Between 0.8 to 1 : 1	0.5 – 0.55 : 1
Life span	3 years	Estimated 10-15
Investment	Low	High

The traditional kiln is not of low capacity but also the efficiency is very low. It has advantages if the demand is low. But at a high demand rates, continuous kiln are much better and investment cost is seven times higher than traditional kiln.

Table B6.17: Energy consumption in jaggery factories

	Edirisa's Factory	Mwagele sugar Cane factory	Nakirya and Company	Alikoba Enterprise
Source of energy	Diesel generator	Grid Electricity	Grid Electricity	Grid Electricity
Engine /motor Specification	7.9 kW	25kW	45 HP	10 HP
Daily sugarcane Consumption (tons)	6	14	7	7
Daily electricity energy consumption	0.406 GJ	0.324 GJ	0.18 GJ	0.19 GJ
Daily firewood Consumption –tonne	25.6GJ	44.8 GJ	16 GJ	19.2 GJ
Daily bagasse Consumption –tonne	5.41 GJ	21.62 GJ	10.81 GJ	9.27 GJ
Daily jaggery output	0.45 (tonnes)	1.0(tonnes)	0.5(tonnes)	0.5(tonnes)
Specific energy consumption MJ/kg	69.82	66.74	53.98	57.32 MJ

At all the four jaggeries the specific energy consumption is higher for the capacity manufactures. The grid connected factories high capacity factories have the better specific energy consumption.

Table B6.18: Types of barns and their specific fuel consumption

Type of Barns	Specific Fuel Consumption	Year of introduction
Conventional	15 –16	1980's
Malawi	8	1990's
Mark III	7-8	1990's
Mark IV	7	1990's
Venturi	5-3.5	Present

There is a drive to improve on the efficiency of tobacco kilns in both West Nile and Rukungiri. The improvements which began in 1990's have reduced the fuel consumption by over 3 times.

Table B6.19: Specific energy consumption in tobacco curing in West Nile Region

Year	Tobacco (tons)	Wood fuel	Specific fuel consumption (MJ/kg)
1998	6,434	102,000 m^3	6.67
1999	9,876	88,000 m^3	3.74
2000	7,828	79 ,000 m^3	4.2

In the West Nile region within only two years, the specific energy consumption was reduced by over 35 %.

Table B6.20: Tea production and specific energy consumption

Factory	Fuelwood (m^3)	Electricity kWh	Tea produced (kilograms)	Specific energy consumption MJ/kg
Rwenzori HL	5,224	1,470,646	2,750,000	11.96
Igara Tea Growers	2,885	920,040	1,586,973	11.4
Kyanyonza T.F	2,628	815,015	1,340,330	12.35
Ankole Tea E.	5,103	1,259,171	1, 888,719	17.02
Bugume Tea .E	5,295	1,310,527	2,083,695	16.02

The Igara Tea Growers factory has low specific energy consumption because it was among the tea factories which were rehabilitated.

Table B6.21: Student Enrolment and Number of Primary Schools, 1997-2000

Total	1997	1998	1999	2000
Students enrolment	5,303,564	5,806,385	6,288,329	6,559,013
Percentage increase	93.75	9.8 %	8.3%	4.3%
Number of schools	8,550	9,916	10,597	11,578
Percentage increase	0.2 %	16%	6.8 %	9.2 %

In 1998, there was a large increase in the number of students' enrolment in primary school because of the government policy of free primary education.

Table B6.22: Student Enrolment and Number of Secondary Schools, 1997-2000

Total	1997	1998	1999	2000
Students enrolment	245,676	265,676	458,263	581,931
Percentage increase	3 %	8.1%	72.5%	27%
Number of schools	621	837	1,633	1,892
Percentage increase	0.3%	35%	95%	15%

As the result of increment in primary school, there was corresponding increase in number secondary schools.

Table B6.23: The Status of Primary and Secondary Schools, 2000

Status	Primary Schools		Secondary Schools	
	No. of Primary	Percentage	No of Secondary	Percentage
Full boarding	102	0.88	178	9.4
Partly Boarding	661	5.71	621	32.8
Day	10,788	93.2	1,093	57.8
Others	27	0.21	0	0
Total	11,578	100	1,892	100

Most of the primary schools are day schools, while more than 40% of the secondary schools are either full boarding or mixed (boarding and day)

Table B6.24: Energy Consumption in Selected Secondary Schools.

School	No of students	Woodfuel Annual (tonnes)	Electricity kWh	LPG (kg)	Energy per student (MJ) Per day
Gayaza High S.	840	266	132,405	1,500	19.59
Nabisunsa G.S.	920	300	120,215	3,000	20.40
Trininty Collage	850	373	117,643	-	22.11
St. Lawrence. C.	950	147	132,808	2,000	14.49
Namiryango C.C	1000	200	121,122	2,029	13.06
Makerere Collage	1150	270	138,128	2,000	12.52
Kibuli S.S	1200	410	144,657	-	20.59
Kings Collage	1070	285	138,840	-	21.20
Kawempe Muslim	950	315	122586	-	20.14
St.Marys Kisubi	1200	210	141,089	-	17.77

Most of the schools depend on biomass for cooking. There is increasing use of LPG for cooking in the schools. The school which uses LPG has lower energy consumption per student because the fuel has high calorific values and appliances are efficient.

Table B6.25: Biomass Energy Consumption in Primary and Secondary Schools

	Primary School		Secondary Schools	
Status	No students	Energy (PJ)	No students	Energy (PJ)
Full Boarding	55,337	0.22	43,077	0.22
Partly Boarding	269,298	0.57	112,733	0.34
Day Schools	1,174,786	1.22	79,463	0.13
Total	1,499,421	2.01	235,272	0.59

The numbers of primary schools are much higher than secondary schools because it takes 7 years to complete primary school while it takes 6 years to complete secondary level. There are also a number of drop outs at primary level.

Table B6.26: Energy Consumption in Makerere University Halls of residence

Hall of residence	No. of students	Firewood (TJ)	Electricity	Gas (TJ)
Complex Hall	800	2.70	1.12	0.13
Michael Hall	735	2.43	1.02	0.17
University Hall	647	2.93	0.95	0.25
Africa Hall	650	2.48	0.92	0.18
Mary Stuart Hall	863	2.78	1.23	0.16
Livingstone Hall	797	2.63	0.95	0.29
Nsibirwa Hall	1365	5.15	1.61	0.40
Lumumba Hall	1350	6.44	1.60	0.37
Total	7,197	27.51	9.41	1.93

Biomass was the main source of energy in Halls of Residence in Makerere University. The installation of LGP started in 1997. In 2005 all the Halls of Residences replaced LPG with firewood.

Table B6.27: Biomass Energy Consumption in Commercial Sector (PJ)

Institution	Fuelwood	Charcoal	Total
Small hotels and restaurants	3.362	3.617	6.979
Breweries and Distilleries	9.19	0	9.19
Bakeries	0.44	0	0.44
Schools	2.60	0	2.60
Hospitals	0.204	0.126	0.33
Prisons	0.132	0	0.33
Total	15.928	3.743	19.869

Local breweries and distilleries are leading consumers of biomass in the commercial sector. They use three-stone open fire in brewing and distilling process. They are followed by small scale hotels and restaurants.

Table B6.28: Regional prices of petroleum products in 2000

Country	Fuel price US$ per litre	
	Super	Diesel
Uganda	0.86	0.75
Kenya	0.71	0.60
Tanzania	0.76	0.73
Rwanda	0.89	0.84
Sub-Saharan Africa	0.59	0.43
Low income countries	0.49	0.31

The price of petroleum is fluctuating world wide. The prices of petroleum products are higher in the East African Region that other Sub-Saharan due to high taxation.

Table B6.29: Regional Traffic in 2000

Country	Motor vehicles per 1000 people	Passenger cars per 1000 people
Uganda	6	2
Kenya	13	10
Tanzania	5	1
Rwanda	4	2
Sub-Saharan Africa	7	4
Low income	10	5

Source 2001 World Development Indicators page 171-175

The number of motor vehicles and passenger car per 1000 people in Uganda is very low when compared with sub-Saharan Africa and Low income countries. Consequently emission in the transport sector is not a major problem in Uganda.

Table B6.30: Road passenger vehicle kilometres (million)

Passenger	No vehicles	Vehicle-km	Vehicle-km (million)
- Bus	770	55,000	42.35
- Minibus (petrol)	8,400	55,000	461.978
- Car	48,942	20,000	978.84
- Motorcycles	7,636	10,000	76.36
- Minibus(diesel)	6,872	50,000	343.62
Total			1,903.148

The most common means of public transport is minibuses. They are commonly used in urban region. The use of buses is limited to long routes.

Table B6.31: Road passenger energy intensity (MJ/passenger)

Passenger	Load Factor	Passenger –km (million)	Energy Intensity (MJ/passenger)
- Bus	45	1,906	0.209
- Minibus (petrol)	10.5	4,851	0.451
- Car	2.5	2,447	1.206
- Motorcycles	1	76	1.326
- Minibus(diesel)	10.5	3,608	0.449

In spite of the fact that energy intensity per passenger is lower by bus, the most common means of transport is by minibus. They minibuses employ a large number of people. It will not be easy to introduce buses in Kampala City. Motorcycles have high energy intensity per passenger.

Table B6.32: Road freight vehicle kilometres (million)

Freight	Tonne	Kilometres	Tonne kilometres
- Heavy commercial	12,801	30,000	384.03
- Pick up (petrol)	24,823	20,000	496.464
- Pickup (diesel)	16,549	20,000	330.976
Total			1,211.47

Pick up is the mostly commonly used means of transporting merchandise

Table B6.33: Road freight energy intensity (Mega Joule/ tonne-km)

Freight	Load Factor	Tonne – km (million)	Energy Intensity (MJ/tonne-km)
- Heavy commercial	15	5,760	0.9424
- Pick up (petrol)	1	496	0.4736
- Pickup (diesel)	1	331	0.4712

The energy intensity for heavy commercial is higher than the pick-up.

Table B6.34: Fuel consumption by locomotives

Year	Tonne – kilometre	Fuel consumption	Energy Intensity GJ/tonne
1996	184,271,593	3,778,630	0.758
1997	147,739,755	2,861,805	0.716
1998	147,740,963	2,338,771	0.585
1999	199,588,232	3,072,931	0.569

The energy intensity decreases with increasing tonne-kilometre. At partial loading the intensity increases. The railway is facing stiff competition form heavy commercial transporters.

Table B7.1: Projected Energy Demand Elasticities

Energy forms	With respect to	Base	Low	High
Aviation Fuel	Transport to GDP	1.10	1.00	1.33
Gasoline	Transport to GDP	1.10	1.00	1.33
Kerosene	Monetary GDP	1.00	1.00	0.75
Auto Diesel	Transport to GDP	1.00	1.00	1.33
Industrial Diesel	Industry GDP	1.00	0.8	1.25
Fuel Oil	Industry GDP	1.50	0.8	1.25
LP Gas	Monetary GDP	1.00	1.00	0.75
Electricity	Monetary GDP	1.00	1.70	1.00
Woodfuel-Urban households	Urban population	1.00	0.90	1.10
- Urban non-households	Monetary GDP	1.00	1.00	1.10
- Rural household	Rural Population	1.00	0.90	1.25
- Rural Non Households	Agriculture GDP	1.00	1.00	0.80
Non- Commercial energy				
Woodfuel - Rural households	Rural population	1.00	1.00	1.00
- Rural non-households	Agriculture GDP	1.00	1.00	1.00

Elasticities used by the World Bank / UNDP when they carried out energy demand projects in Uganda under: Issues and Options in the Energy Sector, UNDP/World Bank Energy Sector Assessment Program, July 1983

Table B7.2: Selected explanatory variable

Sector	Explanatory variables
Industrial	Manufacturing products
Commercial and street lighting	Monetary
General	Monetary

The explanatory variables used in projection of electricity energy demand projection in the EDF study in September 1998.

Table B7.3: Elasticity of sales to the explanatory variables

Sector	1994	1995	1996	1997
Industrial	1.11	1.15	1.38	1.67
Commercial	1.09	1.31	1.97	2.80
General	0.81	0.92	1.43	1.96

.
The elasticity of sales to explanatory variables used in the Optimisation Study Load Forecast by EDF in September 1998.

APPENDIX E

E.1 : QUESTIONNAIRE FOR INDUSTRIAL ENERGY CONSUMPTION

Company Name : ………………………………………………………..

Address :……………………………………………………………………

Location Office ………………………………………………………….

Factory:………………………………………………………..

General Manager…………………………………………………………..

Contact Person.……………………………………………………………….

Title: ………………………………………………………………………….

Telephone:………………………………………………….

Fax:…………………………………………………………….

1.0 General Information

1.1 Industry in which the factory is classified:……………………………….

1.2 Date of Commissioning.……………………………………………………..

1.3 Operation time :…………………………………………………………………….

Hours per day.………………………………………………………………….

Days per year.……………………………………………………………………

1.4. No. of employees ……………………………………………………………

2.0 Processing Activities:

2.1 Provide a flow sheet of the plant indicating major operation

2.2 List different process units e.g. Milling, boiler, evaporation, electricity generation

....

....

2.3 Are by-products or waste products of this plant utilised elsewhere :

....

3.0 Energy Utilisation

3.1 What process unit / department are the major consumer of each type of energy

Process unit	Type of energy	Quantity

3.2 What percentage, approximately, do energy costs present in relation to the total production cost ? ....

4.0 Electricity Consumption

4.1 What is the installed total capacity of motors and other equipment (kW)

4.2 Is electricity generated at the plant ? ....

4.3 What is the installed generation capacity (MW) ....

5.0 Fuel Used For Self Generation

5.1 Annual energy consumption

Fuel type	Units	Quantity consumed

5.2. Is self generating capacity to be increased ?

5.3 What is the average power factor for the plant ?

5.4 Combined heat and power generation (Co-generation)

Energy Source	Energy produced	Level of steam and electricity production (kW)

5.5 .When was the system installed ? ....

5.6. Are there plans to increase the capacity of the existing system ?

....

6.0 Energy Management and Conservation

6.1 Does the plant currently have an energy conservation / saving program

....

6.2. If yes, what does this program consist of ? What are the target areas ?

....

6.3 . Who is responsible for energy management ?

....

6.4 What energy conservation measures have been identified to –date

....

6.5 Does that plant have adequate information and literature concerning energy conservation and audit procedure ?

....

6.6 . How is energy consumption examined and monitored.

....

6.7 What analysis of energy consumption was carried out.

....

6.8 To what extent is record –keeping of energy consumption is practiced ?

....

6.9 Give summary of energy consumption and costs

....

7.0 Monthly Summary of Energy Consumption and Costs

7.1 Give summaries of energy consumption and costs for two previous years.

Year ....

Month	Electricity	Cost	Fuel	Cost	Biomass	Cost

January						
February						
March						
April						
May						
June						
July						
August						
September						
October						
November						
December						
Total						

Year ....

Month	Electricity	Cost	Fuel	Cost	Biomass	Cost
January						
February						
March						
April						
May						
June						

July						
August						
September						
October						
November						
December						
Total						

Table E. 2 : List of Major Industries Visited

No	Name	Location	Major products/Service
1	SCOUL	Lugazi	Sugar
2	Kakira Sugar Works	Jinja	Sugar
3	Tororo Cement Works	Tororo	Cement
4	Hima Cement Industry	Kasese	Cement
5	Nyanza Textile	Jinja	Textiles
6	Steel Rolling Mills	Jinja	Steel products
7	National Sewage corporation	Kampala	Water and sewage
8	Diary corporation	Kampala	Milk
9	British American Tobacco	Kampala	Tobacco
10	Uganda clay works	Kajansi	Tiles and bricks
11	Allied Clay works	Kajansi	Tiles and bricks
15	Parombo cotton ginnery	Parombo	Lint
16	Musumba Coffee Factory	Kibale	Coffee
17	Kagadi Coffee Factory	Kibale	Coffee
19	Mwenge Tea Estate	Toro	Tea
20	Rwenzore Tea Estate	Toro	Tea
21	Igara Tea Estate	Kabale	Tea
22	Century Bottling Ltd	Kampala	Beverages
23	Nile Breweries Ltd	Jinja	Beer
24	Uganda breweries Ltd	Kampala	Beer
25	Rami Milk	Mbarara	Milk
26	Kasese Cobalt Ltd	Kasese	Cobalt
27	Edirisa Jaggery	Kamuli	Jaggery
28	Alikoba Enterprises	Kamuli	Jaggery
29	John Lugendo Lime works	Tororo	Lime

30	Mawakato Lime works	Tororo	Lime
31	Pakwach cotton ginnery	Pakwach	Lint

APPENDIX C

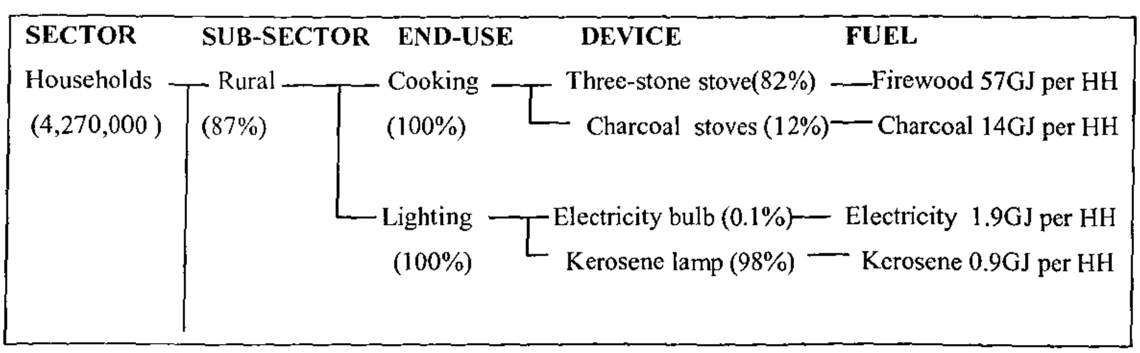
The Long-range Alternative Energy Planning (LEAP) is one of the commercial software commonly used world-wide in areas of energy and environmental studies. It finds applications in many developing countries. It is flexible in application to various energy scenarios. The software was developed by Stockholm Environment Institute. Since its inception, there were many versions, which were produced. The latest is being version 2003. In this thesis version 2000 was used for energy projection.

Energy Scenarios for Uganda was developed using modelling techniques, which require energy demand forecast for all sectors of the Ugandan economy. This simulating model was used to present the current energy requirement for Uganda and developed forecast for future energy demand under certain assumptions. The model is good tool for energy planning which can be used to perform demand and supply analysis, develop forecast, to identify gaps between demand and supply and to perform environmental impact assessment.

The objective of the LEAP is to provide a computer-based approach for fostering integrated, reliable energy planning. The LEAP system consists of three blocks of programmes: energy scenarios, aggregation, and the environmental database. The Energy Scenarios, programmes address the main component of integrated energy analysis: demand analysis, energy conversion and resource assessment.

Demand :

LEAP follows end use demand-driven approach, which means that analysis starts from the end use of energy. The demand programme is in form of hierarchical tree structure of four levels: sectors, sub-sectors, end-use and devices. As an example to determine energy consumption in households, a tree structure is as illustrated below.



SECTOR	SUB-SECTOR	END-USE	DEVICE	FUEL
	Urban (13%)	Cooking (100%)	Electric cooker (%5)	Electricity (31GJ per HH)
			Charcoal stoves (%75)	Charcoal (24GJ per HH)
			Three stone stoves (20%)	Firewood (56GJ per HH)
			LPG stoves (2%)	LPG MJ (6.8 GJ per HH)
		Lighting (100%)	Electric bulb (40%)	Electricity (5.8MJ per HH)
			Kerosene lamp (60%)	Kerosene (1.4GJ per HH)

The Environment Data Base (EDB) provides a compressive summary of the information linking energy production, conversion and consumption to air emissions.

Energy Scenario Programs

The four programmes for building scenarios (Demand, Transformation, Biomass, Land Use) allow the development of energy supply and demand.

The Demand program provides disintegrated end-use approach to analysis of energy requirements.

Activities are entered directly by the user or computed using user supplied growth rates, macro drivers, are multiplied together, then multiplied by the energy intensity entered at the devise level. The result is the energy demand for a particular device in the present and up to the future years. Demand by device is summed up the LEAP to yield the total energy demand for country being studied.

The Transformation

The Transformation programs simulate the energy sector conversion process that turns primary energy sources into final fuels. The programs compare the primary sources and fuel imported and exports required to provide the final fuel consumption calculated by the demand programme. Specialised modules handle major transformation processes that are available from existing data base of modules, but the user can define new modules as well.

Biomass Requirement

Biomass requirements computed by the transformation program are used by the Biomass Resource modules to match biomass resource demand to available wood stock and yield. The Biomass Resource and Land Use programs examine the impact of biomass demand and land use changes on the biomass resource base. Biomass projections are based on the inventory of wood stocks and yield.

Limitation of LEAP

LEAP is limited in some aspects, for instance, it does neither attempt to estimate the impact of energy policies on employment nor can it automatically generate optimum or market equilibrium scenarios. In such cases LEAP can be used in conjunction with other software.

APPENDIX D

Table A5.1: Household Energy Survey Questionnaire

National Household Energy Survey

Section A General Information

NOTE: 1. Use capital letters when filling the questionnaire
2. Tick appropriately

1.0	Date of Interview.		
2.0	Interviewers name		
2.1	Supervisors Name		
3.0	Centre Name and Address		
4.0	Area of Interview –choose one (name)		
		Urban	
		Suburban	
		Trading Centre	
		Village	
		Sub-county	
5.0	District		
6.0	Region		
7.0	How many people live in the household (fill according to age)		
	Less than 14 years		
	Female over14 years		
	Male between 15 -59 years		
	Male over 59 years		
8.0	Head of household		M
9.0	Age of the respondent		
10.0	Estimate total income of all the people living in the household Monthly Income (Tick appropriate box) Low (less than 50,000) Medium(51,000-150,000) High more than 150,000)		
11.0	Housing Unit		
11.1	Main type of dwelling unit		
11.2	Sun dried bricks		
11.3	Mud and wattle		
11.4	Bricks and wood construction		
11.5	Straw and mud		
11.6	Fired bricks construction /concrete block		
11.7	Others specify		
12.0	Main roofing material of the dwelling		
12.1	Galvanised iron sheet		
12.1	Galvanised iron		

	sheet		
12.2	Straw (spear grass, papyrus etc.)		
12.3	Tiles /asbestos		
12.4	Banana fibre leaves		
13.0	Is the house used for any commercial activities		
	What type of business or commercial activities		
13.1	Retail store		
13.2	Repair tool shop		
13.3	Bar		
13.4	Making hand crafts		
13.5	Restaurant		
13.6	Grocery and beverages shop		
13.5	Hair dressing /barber		
13.6	Others specify		
13.0	Does your household rent or own this house.		

Section B Information on Energy

14.0	Sources of Energy for Lighting and percentage use		
14.1	Kerosene		%
14.2	Diesel Generators		%
14.3	Gas		%
14.4	Car battery		%
14.5	Dry cell battery		%
14.6	Candles		%
14.7	Electricity from the household own PV panel		
14.8	Electricity		%
14.9	Other.		%

15.0	Sources of Energy for Cooking food and Heating of water					
	Percentage use	0-25 %				2(
15.1	Charcoal					
15.2	Firewood					
15.3	Small tree branches					
15.4	Scrap wood.					
15.5	Agriculture residue					
15.6	Electricity					
15.7	Kerosene					
15.8	Others specify.					

15.9 On average, how much woodfuel do the household use per week?

Bundles	3		Bundles	4	
Bundles	5		Bundles	7	

16.0	Who collects fire wood?			
16.1	Children		How many	
16.2	Adult		How many	

17.0	What is the source of fire wood ?
17.1	Forest ☐ Market ☐
17.2	What is the distance travelled to get fire wood?
18.0	Types of Stoves used
18.1	Three stones
18.2	Ceramic Sigiri
18.3	Metal sigiri
18.4	Improved Stoves for firewood.
18.5	Pressurised Kerosene Stoves.
18.6	Kerosene Wick Stove.
18.7	Stove with chimney made of brick and cement.
18.8	Others specify.
19.0	What is the cost of the improved stove ? Shs.
20.0	On average how does the household spend on the following:
20.1	Electricity Shs. Per month
20.2	Kerosene Per month
20.3	Charcoal Per month
20.4	Woodfuel Per month
20.5	Total Per month
21.0	What is the price of a litre of kerosene
21.1	How much does the household purchase in a month
21.2	Jerrican (5 litres)
21.3	Beer bottle (0.5iltres)
21.4	Soda bottle (0.3 litres)
21.5	Jerrican (20 litres)
21.6	How many hours does the household use kerosene lamp
22.0	Charcoal
22.1	How many normal bags in a week
22.2	How many small bags in a week
22.3	How many large tins in a week
22.4	How many small tins in a week
23.0	How many wick lamps (todoba) does your household have ?
23.1	How often does your household use wick lamp?
	Never ☐ Rarely ☐
	Sometimes ☐ Always
24.0	How many pressurised kerosene lamps
	Does your household have?
25.0	How often does your household use pressurised kerosene lamp?
	Never ☐ Rarely ☐
	Sometimes ☐ Always ☐
26.0	How many hurricane lamps does your household have ?
27.0	How often does your household use hurricane lamp?
	Never ☐ Rarely ☐
	Sometimes ☐ Always ☐
28.0	Do you use liquid petroleum gas (LPG)

28.1 How much do you use in a month (Kg)
28.2 How much do you spend on LPG in a month (Shs)
29.0 How much Diesel do you use for:
29.1 Lighting (litres)
29.2 Cooking
29.3 Total for electric generation
29.4 How many hours do run the generators in day
30.0 Are you connected to the grid

31.0 What are electrical appliances in households State the hours the appliances are utilised daily
31.1 TV
31.2 Radio
31.3 Refrigerator
31.4 Electric cooker
31.5 Air conditioners
31.6 Flat iron
31.7 Hot water
31.8 Washing machine
31.9 Electric kettle
31.10 Vacuum Cleaner
32.0 Car battery
32.1 How many batteries does your household have
32.2 Which size of batteries does your household have
32.3 How long does a recharged batteries last
ch does the household spend on batteries (Shs.)
32.5 What are the main uses of the battery
32.6 Lighting
32.7 Radio
32.8 Television
32.9 Car batteries used as the main source of power?
32.10 On average how many hours do you use batteries in a day
33.0 Dry cell batteries
33.1 What are the main uses of the dry cells?
33.2 Radio/Tape recorder
33.3 Flashlight
33.4 Others specify
33.5 On the average how much does the household spend on dry cells
Per month Ushs.
33.6 How many dry cells does the household purchase per month?
33.7 How long do the dry cells batteries last? (days)
33.8 What is the cost of pair dry cells batteries? Shs.

34.0 What do you comment on the domestic energy situation in the

Locality or areas you made the survey ?

35.0 What are the possible solutions

APPENDIX E

E.1 : QUESTIONNAIRE FOR INDUSTRIAL ENERGY CONSUMPTION

Company Name : ....

Address :..

Location Office ....

Factory:..

General Manager..

Contact Person..

Title: ....

Telephone:..

Fax:..

1.0 General Information

1.1 Industry in which the factory is classified:...................................

1.2 Date of Commissioning...

1.3 Operation time :..

Hours per day..

Days per year..

1.4. No. of employees ....

2.0 Processing Activities:

2.1 Provide a flow sheet of the plant indicating major operation

2.2 List different process units e.g. Milling, boiler, evaporation, electricity generation

....

....

2.3 Are by-products or waste products of this plant utilised elsewhere :

....

3.0 Energy Utilisation

3.1 What process unit / department are the major consumer of each type of energy

Process unit	Type of energy	Quantity

3.2 What percentage, approximately, do energy costs present in relation to the total production cost ? ....

4.0 Electricity Consumption

4.1 What is the installed total capacity of motors and other equipment (kW)

4.2 Is electricity generated at the plant ? ....

4.3 What is the installed generation capacity (MW) ....

5.0 Fuel Used For Self Generation

5.1 Annual energy consumption

Fuel type	Units	Quantity consumed

5.2. Is self generating capacity to be increased ?

5.3 What is the average power factor for the plant ?

5.4 Combined heat and power generation (Co-generation)

Energy Source	Energy produced	Level of steam and electricity production (kW)

5.5 .When was the system installed ? ……………………………………

5.6. Are there plans to increase the capacity of the existing system ?

……………………………………………………………………………………………

6.0 Energy Management and Conservation

6.1 Does the plant currently have an energy conservation / saving program

……………………………………………………………………………………………

6.2. If yes, what does this program consist of ? What are the target areas ?

………………………………………………………………………………………………

6.3 . Who is responsible for energy management ?

……………………………………………………………………………………………..

6.4 What energy conservation measures have been identified to –date

………………………………………………………………………………………………..

6.5 Does that plant have adequate information and literature concerning energy conservation and audit procedure ?

………………………………………………………………………………………………

6.6 . How is energy consumption examined and monitored.

………………………………………………………………………………………………

6.7 What analysis of energy consumption was carried out.

……………………………………………………………………………………………

6.8 To what extent is record –keeping of energy consumption is practiced ?

………………………………………………………………………………………………

6.9 Give summary of energy consumption and costs

………………………………………………………………………………………………

7.0 Monthly Summary of Energy Consumption and Costs

7.1 Give summaries of energy consumption and costs for two previous years.

Year ………………………………………………………………………….

Month	Electricity	Cost	Fuel	Cost	Biomass	Cost

January						
February						
March						
April						
May						
June						
July						
August						
September						
October						
November						
December						
Total						

Year ....

Month	Electricity	Cost	Fuel	Cost	Biomass	Cost
January						
February						
March						
April						
May						
June						

July						
August						
September						
October						
November						
December						
Total						

Table E. 2 : List of Major Industries Visited

No	Name	Location	Major products/Service
1	SCOUL	Lugazi	Sugar
2	Kakira Sugar Works	Jinja	Sugar
3	Tororo Cement Works	Tororo	Cement
4	Hima Cement Industry	Kasese	Cement
5	Nyanza Textile	Jinja	Textiles
6	Steel Rolling Mills	Jinja	Steel products
7	National Sewage corporation	Kampala	Water and sewage
8	Diary corporation	Kampala	Milk
9	British American Tobacco	Kampala	Tobacco
10	Uganda clay works	Kajansi	Tiles and bricks
11	Allied Clay works	Kajansi	Tiles and bricks
15	Parombo cotton ginnery	Parombo	Lint
16	Musumba Coffee Factory	Kibale	Coffee
17	Kagadi Coffee Factory	Kibale	Coffee
19	Mwenge Tea Estate	Toro	Tea
20	Rwenzore Tea Estate	Toro	Tea
21	Igara Tea Estate	Kabale	Tea
22	Century Bottling Ltd	Kampala	Beverages
23	Nile Breweries Ltd	Jinja	Beer
24	Uganda breweries Ltd	Kampala	Beer
25	Rami Milk	Mbarara	Milk
26	Kasese Cobalt Ltd	Kasese	Cobalt
27	Edirisa Jaggery	Kamuli	Jaggery
28	Alikoba Enterprises	Kamuli	Jaggery
29	John Lugendo Lime works	Tororo	Lime

30	Mawakato Lime works	Tororo	Lime
31	Pakwach cotton ginnery	Pakwach	Lint

APPENDIX F

Table F6.1 : Stove Efficiency Testing Sheet

Date:		Start Time		
Type of test:				
Test No:		End Time		
Stove No.				
	High power phase			
	Initial (kg)	Final (kg)	Initial (kg)	
Container weight (c0)				
Weight of charcoal (c1)				
Weight of pot+ water (p1)				
Weight of water (p2)				
Water temperature (tw)				
Time (t) (minutes)				
			High Power Phase	
Charcoal remaining (c2) (kg)				
Charcoal consumed (c1-c2) (kg)				
Water vaporised (me) (kg)				
Duration of test (t2-t1) (min)				
Burning rate (c1-c2)/(t2-t1) (kg/min)				
Dry Bulb (Degrees Centigrade)				
Wet Bulb (Degrees Centigrade)				

The table was used during testing of the stove. Tests were carried for low power and high power phase. Weight of the charcoal, water and stoves were taken. The weighing scale used was to the accuracy of 5 grams.

Table F6.2 : Equations used in stove testing

Efficiency at High Power Phase

In a high power phase, the efficiency of cooking stove η_{hp} is defined as the ratio of the heat consumed in the heating and boiling of water to the total heat input to the system.

$$\eta_{hp} = \frac{Mw * Cpw * (Tb - To) + Me_h Le}{(Mf - Mfe\ ) * Cv}$$

Where:

η_{hp} = the efficiency at high power phase,

Mw = mass of mass of water in the pot (kg)

Cpw = specific heal capacity of water (kJ/kg C)

Tb = the final temperature of water in the pot (^{0}C)

To = initial temperature of water in the pot (^{0}C)

Me_h = mass of water evaporated (kg)

Le = latent heat of water (MJ/kg)

Mf = initial mass of fuel (kg)

Mfe = final mass of the fuel (kg)

Cv = the calorific value of fuel (MJ/kg)

The fuel burning rate (Mf_{hp}) . It the rate at which charcoal is burnt.

$$Mf_{hp} = \frac{(Mf - Mfe)}{t_b}$$

Where, t_b is the time to biol.

Power output is the amount of amount of energy in a given time. It was computed from :

$$P_{hp} = \frac{(Mf - Mfe) * Cv}{t_b}$$

Specific fuel consumption is the amount of charcoal equivalent used in boiling a given mass of water, divided by the mass of water. It is computed from:

$$S.C_{hp} = \frac{(Mf - Mfe)}{Mw}$$

Efficiency at Low Power Phase

$$\eta_{lp} \frac{Me_{lp} * Le}{(Mfe - Mfe_{lp}) * Cv}$$

Where η_{lp} = Low power phase

Me_{lp} = mass of water evaporated in low power phase

Mf_{lp}= final mass of charcoal in the low power phase.

The fuel burning rate: *(Mfl_{lp})*

$$Mfl_{lp} = \frac{(Mfe_{hp} - Mfe_{lp})}{t_s}$$

Where t_s is the simmering time.

Power output in Lower Power Phase *(P_{lp})*

It the amount of energy released from the appliances at low power phase.

$$P_{lp} = \frac{(Mfe_{hp} - Mfe_{lp}) * Cv}{t_s}$$

Specific fuel consumption (SC_{lp})

$$S.C_{lp} = \frac{(Mfe_{hp} - Mfe_{lp})}{Me_{lp}}$$

The Overall Values

Efficiency (η)

$$\eta = \eta_{hp} * \frac{t_b}{t_b + 30} + \eta_{lp} * \frac{30}{t_b + 30}$$

Fuel burning rates (Mfl)

$$Mfl = Mfl_{hp} * \frac{t_b}{t_b + 30} + Mfl_{lp} * \frac{30}{t_b + 30}$$

Power Output (P)

$$P = P_{hp} * \frac{t_b}{t_b + 30} + P_{lp} * \frac{30}{t_b + 30}$$

Specific Fuel Consumption (S.C)

$$S.c = S.C_{hp} * \frac{t_b}{t_b + 30} + S.c_{lp} * \frac{30}{t_b + 30}$$

The above formulas were used to compute various parameters associated with stoves testing such as the efficiency, power output and specific fuel consumption.

Table F6.3 : The overall value of the stove performance.

OVERALL VALUES						
Stove Number	Burning rate (kg/min)	SFC	Efficiency	Power output (kW)	Boiling time (min)	Lighting time (min)
1	0.00400	0.1163	32.62%	1.783	38.00	7.5
2	0.00467	0.1160	34.84%	2.082	30.33	5.5
3	0.01059	0.1886	25.10%	4.722	21.33	7.6
4	0.00398	0.1127	28.85%	1.776	50.00	7.7
5	0.00411	0.1133	34.18%	1.833	34.33	6.5
6	0.00841	0.1310	35.44%	3.752	21.33	6.0
7	0.00565	0.1374	29.01%	2.520	32.00	5.7
8	0.00568	0.1518	27.46%	2.532	29.33	6.5
9	0.00595	0.1857	23.88%	2.652	28.33	5.9
10	0.00781	0.2190	22.01%	3.483	23.00	8.7

The results of the ten stoves tested as given in the above table.
SFC is the specific fuel consumption.

APPENDIX G

Time Series Exchange for UG.Shs with USD

Annual foreign exchange rates (Uganda Shillings per US$), 1990-1994)

YEAR	UGShs Verse US$
1990	320
1991	531
1992	1145
1993	1195
1994	979
1995	969
1996	1045
1997	1083
1998	1290
1999	1456
2000	1670
2001	1762
2002	1850
2003	1955
2004	1750

Source : Bank of Uganda